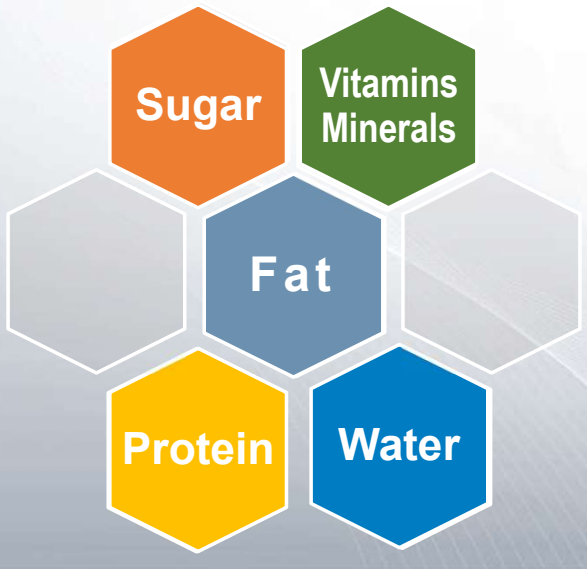
Nutritional Therapy: Top Ten Tenets

For Wound Care

Bob Bartlett MD

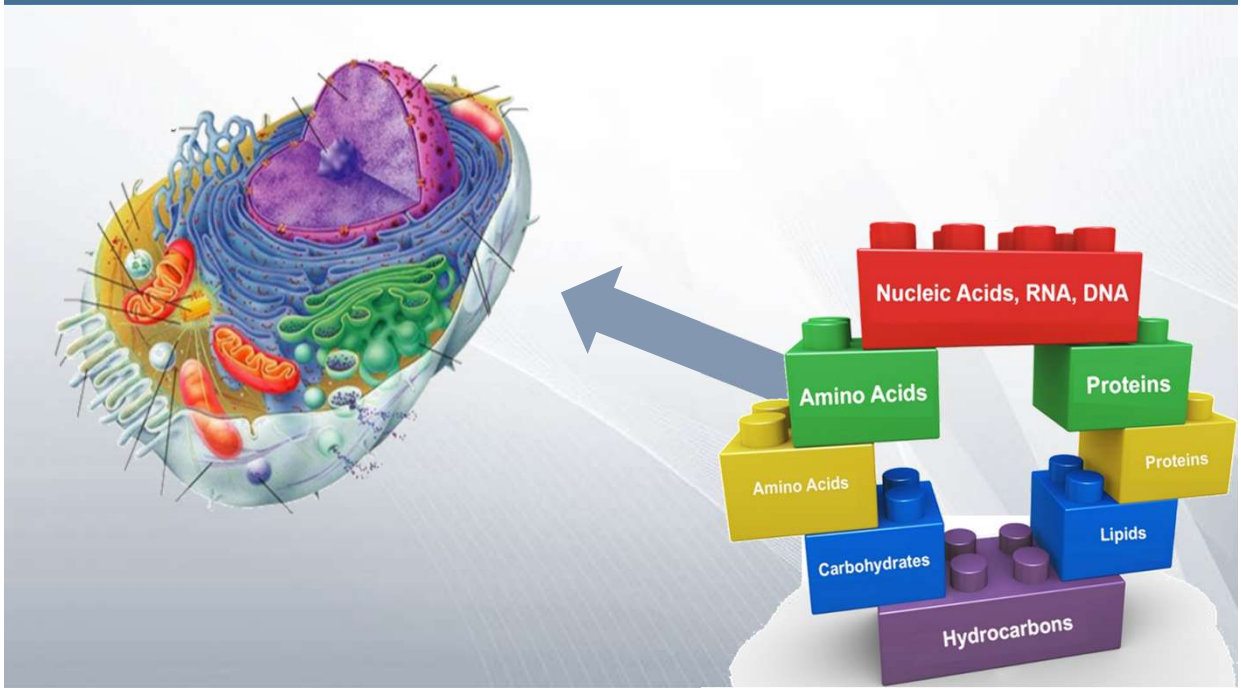
Chief Medical Officer

Nutritional Therapy: Top Ten Tenets

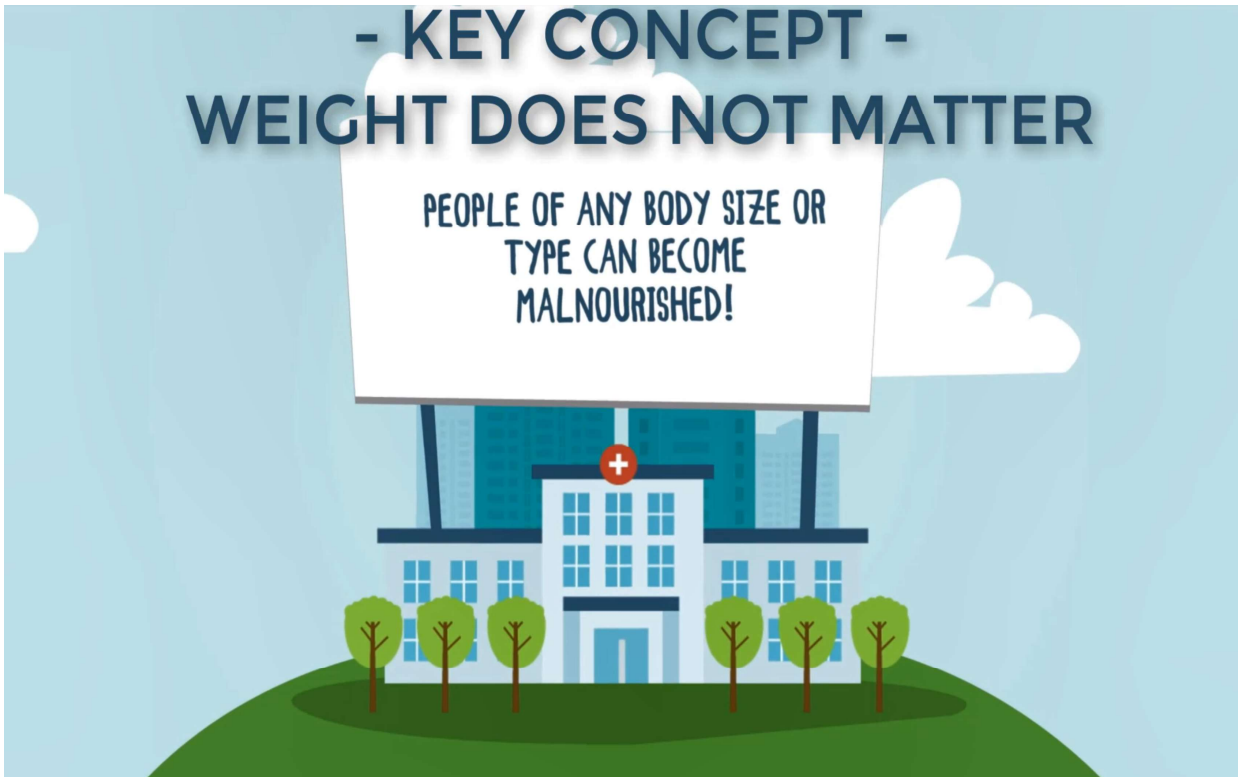


Periodic Table of Nutrition

You can't build cells with antibiotics, dressings or debridement!



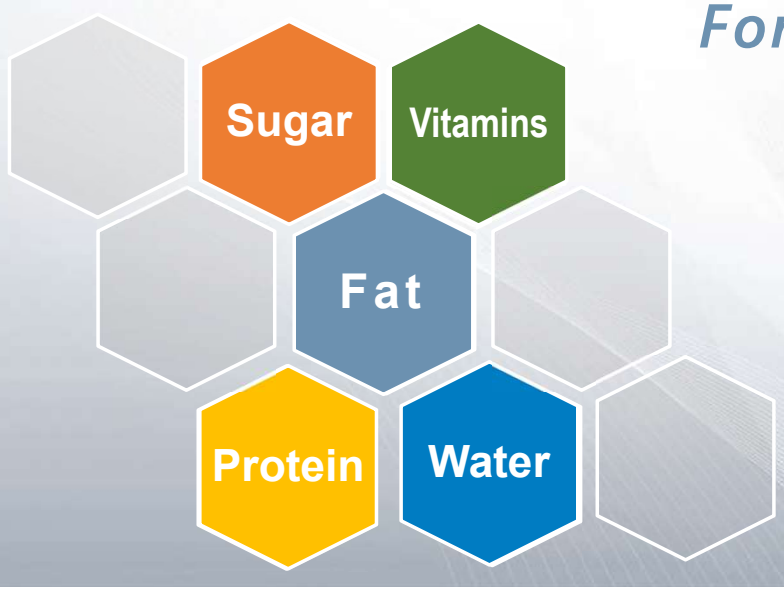
Practical Therapy


- KEY CONCEPT -
WEIGHT DOES NOT MATTER
PEOPLE OF ANY BODY SIZE OR TYPE CAN BECOME MALNOURISHED!


Consumption ≠ Absorption
LEAKY GUT

Nutritional Therapy: Top Ten Tenets

For Wound Care



Sugar

1 - GLYCEMIC CONTROL

It's essential to healing

Routine HbA1c screening for all chronic wounds

Glycemic Control

- Hyperglycemia delays healing, contributes to infection, wound dehiscence, and amputation.
- The importance of glycemic control is *underestimated*. It is often viewed as merely desirable, when in fact it is *essential*.

Target is HbA1c <7% (~*Glucose150 mg %*)

Surgical Site Dehiscence

RECONSTRUCTIVE

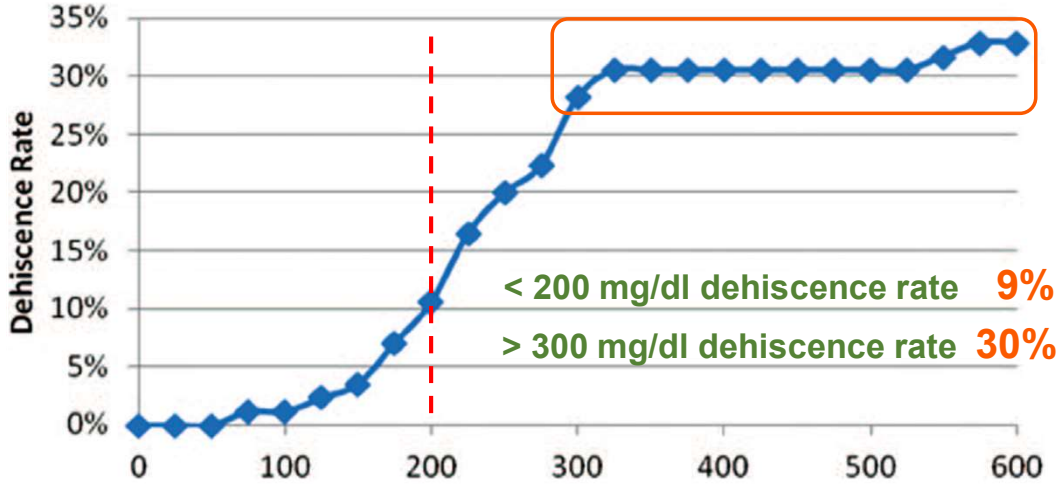
The Role of Chronic and Perioperative Glucose Management in High-Risk Surgical Closures: A Case for Tighter Glycemic Control

Matthew Endara, M.D.
Derek Masden, M.D.
Jesse Goldstein, M.D.
Stephen Gondek, M.D., M.P.H.
John Steinberg, D.P.M.
Christopher Attinger, M.D.
Washington, D.C.; Baltimore, Md.; Philadelphia, Pa.; and Boston, Mass.

Background: The exact risk that poor glucose control introduces to patients undergoing surgical closure has yet to be fully defined.
Methods: The authors retrospectively analyzed a prospectively collected database of patients seen at their wound care center to evaluate the effects of chronic and perioperative glucose control in high-risk patients undergoing surgical wound closure. Hemoglobin A1c and blood glucose levels for the 5 days before and after surgical closure were recorded and compared with the primary endpoints of dehiscence, infection, and reoperation. Univariate and multivariate analyses were performed.
Results: Seventy-nine patients had perioperative glucose levels and 64 had hemoglobin A1C levels available for analysis. Preoperative and postoperative hyperglycemia (defined as any blood glucose measurement above 200 mg/dl) as well as elevated A1C levels (above 6.5 percent or 48 mmol/ml) were significantly associated with increased rates of dehiscence (odds ratio, 3.2, $p = 0.048$; odds ratio, 3.46, $p = 0.028$; and odds ratio, 3.54, $p = 0.040$, respectively). Variability in preoperative glucose (defined as a range of glucose levels exceeding 200 points) was significantly associated with increased rates of reoperation (odds ratio, 4.14, $p = 0.025$) and trended toward significance with increased rates of dehiscence ($p = 0.15$). In multivariate regression, only perioperative hyperglycemia and elevated A1c were significantly associated with increased rates of dehiscence.
Conclusions: In primary closure of surgical wounds in high-risk patients, poor glycemic control is significantly associated with worse outcomes. Every effort should be made to ensure tight control in both the chronic and subacute perioperative periods. (*Plast. Reconstr. Surg.* 132: 996, 2013.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, II.

The important role that tight glucose control plays in optimizing patient outcomes has been accepted in practically all facets of medicine. Large population studies have proven that hyperglycemia interferes with wound healing in patients with ulcers and contributes to increased rates of infection.[1–3] Poor glycemic control has also been associated with increased rates

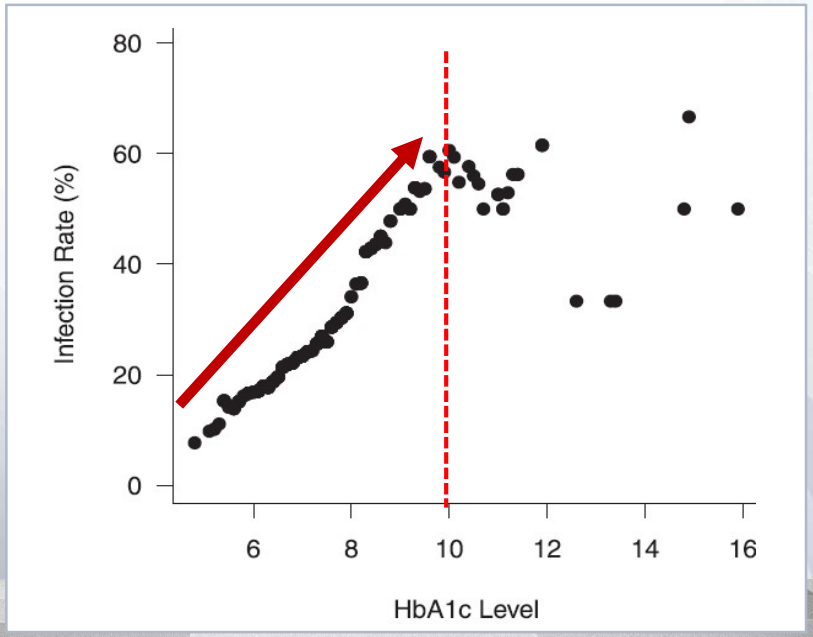
Surgical Site Dehiscence



Preoperative Blood Glucose

Plastic & Recon Surg2013; 132 (4): 996-1004

Infection rates increase steadily as HbA1c increases to 10% and then levels off

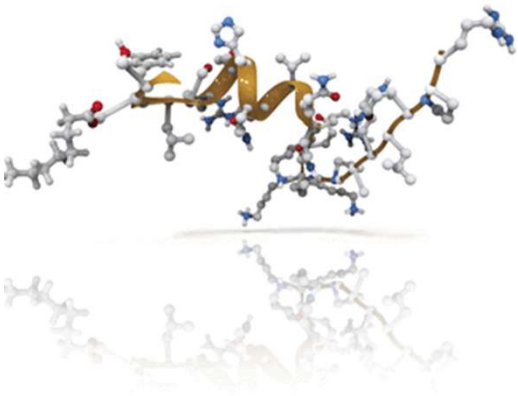


J Foot Ankle Surg. 2014 May-Jun;53(3):307-11

Infection Risk

diabetes

Nielson CP 1989 Aug;38(8):1031-5

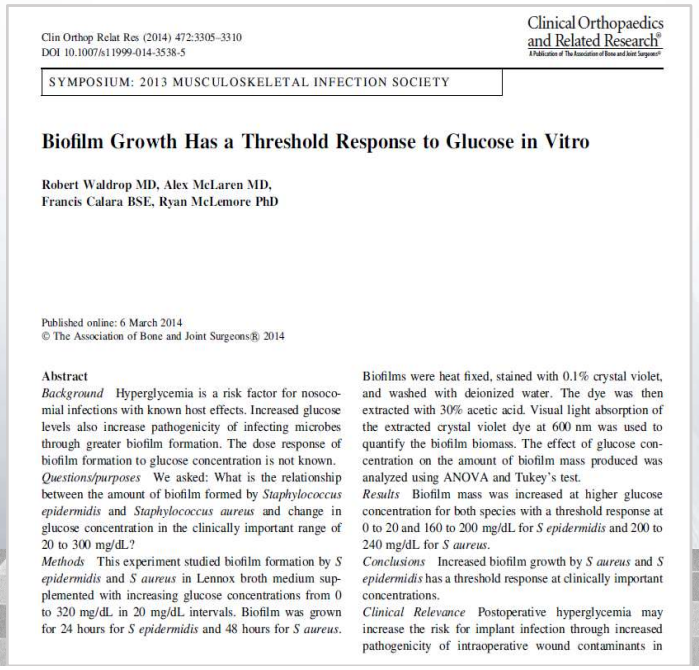


American Diabetes Association.

Neutrophilic function is reduced in proportion to an increase in the glucose level, and 200 mg/dL is the threshold of neutrophil dysfunction.

The respiratory burst was reduced 28% after a 30 min exposure at 200 mg/dL.

Biofilm Growth - Glucose Dependent



Clin Orthop Relat Res (2014) 472:3305–3310
DOI 10.1007/s11999-014-3538-5

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

SYMPOSIUM: 2013 MUSCULOSKELETAL INFECTION SOCIETY

Biofilm Growth Has a Threshold Response to Glucose in Vitro

Robert Waldrop MD, Alex McLaren MD, Francis Calara BSE, Ryan McLemore PhD

Published online: 6 March 2014
© The Association of Bone and Joint Surgeons® 2014

Abstract

Background Hyperglycemia is a risk factor for nosocomial infections with known host effects. Increased glucose levels also increase pathogenicity of infecting microbes through greater biofilm formation. The dose response of biofilm formation to glucose concentration is not known.

Questions/purposes We asked: What is the relationship between the amount of biofilm formed by *Staphylococcus epidermidis* and *Staphylococcus aureus* and change in glucose concentration in the clinically important range of 20 to 300 mg/dL?

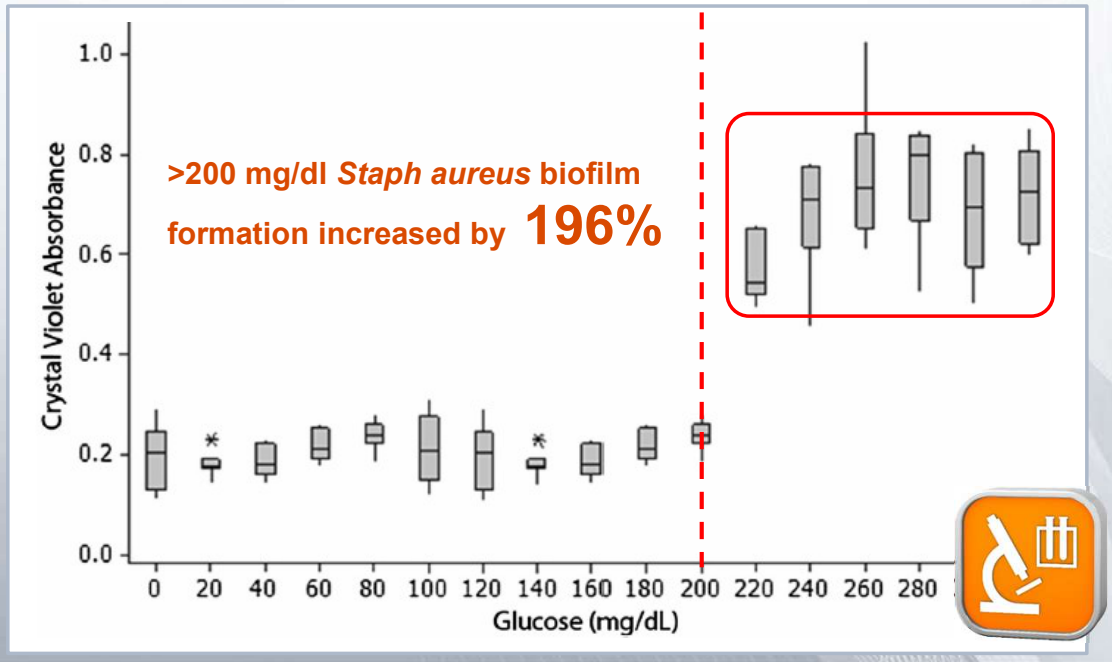
Methods This experiment studied biofilm formation by *S epidermidis* and *S aureus* in Lennox broth medium supplemented with increasing glucose concentrations from 0 to 320 mg/dL in 20 mg/dL intervals. Biofilm was grown for 24 hours for *S epidermidis* and 48 hours for *S aureus*. Biofilms were heat fixed, stained with 0.1% crystal violet, and washed with deionized water. The dye was then extracted with 30% acetic acid. Visual light absorption of the extracted crystal violet dye at 600 nm was used to quantify the biofilm biomass. The effect of glucose concentration on the amount of biofilm mass produced was analyzed using ANOVA and Tukey's test.

Results Biofilm mass was increased at higher glucose concentration for both species with a threshold response at 0 to 20 and 160 to 200 mg/dL for *S epidermidis* and 200 to 240 mg/dL for *S aureus*.

Conclusions Increased biofilm growth by *S aureus* and *S epidermidis* has a threshold response at clinically important concentrations.

Clinical Relevance Postoperative hyperglycemia may increase the risk for implant infection through increased pathogenicity of intraoperative wound contaminants in

Biofilm Growth - Glucose Dependent



Sugar 1 - GLYCEMIC CONTROL

Sugar 2 – SUGAR SUBSTITUTES

It's complicated

Sugar

2 - Sugar Free Pitfalls

Physiol Behav. 2015 Dec 1;152(Pt B):450-5

Metabolic effects of non-nutritive sweeteners

M. Yanina Pepino *

Center for Human Nutrition, Washington University School of Medicine, St. Louis, MO, United States

Until recently, the general belief was that non-nutritive sweeteners (NNS) were healthy substitutes because they provide sweet taste without calories or glycemic effects.

However, data from several studies found they are associated with ***increased risk*** of **obesity, metabolic syndrome**, and **type 2 diabetes**.

Intense sweeteners
Non-caloric sweeteners
Sucralose
Metabolism

homeostasis, 2) NNSs interfere with gut microbiota and induce glucose intolerance, and 3) NNSs interact with sweet-taste receptors expressed throughout the digestive system that play a role in glucose absorption and trigger insulin secretion. In addition, recent findings from our laboratory showing an association between individual taste sensitivity to detect sucralose and sucralose's acute effects on metabolic response to an oral glucose load are

Clinical Care/Education/Nutrition/Psychosocial Research

ORIGINAL ARTICLE

Diabetes Care. 2013

Sucralose Affects Glycemic and Hormonal Responses to an Oral Glucose Load (Splenda)

M. Yanina Pepino, phd
Courtney D. Tiemann, mph, ms, rd
Bruce W. Patterson, phd
Burton M. Wice, phd
Samuel Klein, md

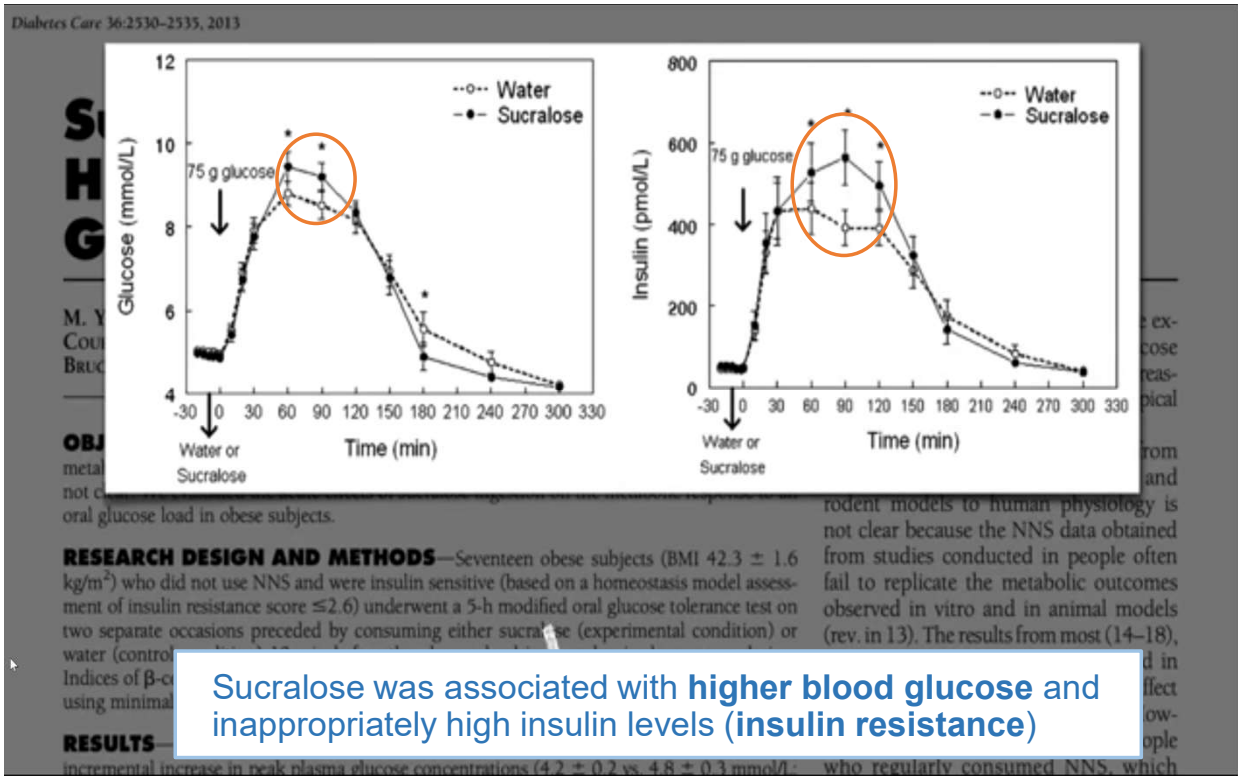
OBJECTIVE—Nonnutritive sweeteners (NNS), such as sucralose, have been reported to have metabolic effects in animal models. However, the relevance of these findings to human subjects is not clear. We evaluated the acute effects of sucralose ingestion on the metabolic response to an oral glucose load in obese subjects.

RESEARCH DESIGN AND METHODS—Seventeen obese subjects (BMI 42.3 ± 1.6 kg/m^2) who did not use NNS and were insulin sensitive (based on a homeostasis model assessment of insulin resistance score ≤2.6) underwent a 5-h modified oral glucose tolerance test on two separate occasions preceded by consuming either sucralose (experimental condition) or water (control condition) 10 min before the glucose load in a randomized crossover design. Indices of β-cell function, insulin sensitivity (S_I), and insulin clearance rates were estimated by using minimal models of glucose, insulin, and C-peptide kinetics.

RESULTS—Compared with the control condition, sucralose ingestion caused *1*) a greater incremental increase in peak plasma glucose concentrations (4.2 ± 0.2 vs. 4.8 ± 0.3 mmol/L; $P = 0.03$), *2*) a 20 ± 8% greater incremental increase in insulin area under the curve (AUC) ($P < 0.03$), *3*) a 22 ± 7% greater peak insulin secretion rate ($P < 0.02$), *4*) a 7 ± 4% decrease in insulin clearance ($P = 0.04$), and *5*) a 23 ± 20% decrease in S_I ($P = 0.01$). There were no significant

glucose absorption by upregulating the expression of sodium-dependent glucose transporter isoform 1 (5,10,11) and increasing the translocation of GLUT2 to the apical membrane of intestinal epithelia (12).

The relevance of the findings from studies conducted in cell systems and rodent models to human physiology is not clear because the NNS data obtained from studies conducted in people often fail to replicate the metabolic outcomes observed in vitro and in animal models (rev. in 13). The results from most (14–18), but not all (19,20), studies conducted in people have found that NNS do not affect plasma glucose, insulin, or GLP-1. However, these studies did not exclude people who regularly consumed NNS, which could have chronic effects on glucose metabolism (5,10,11) that would blunt any



Sucralose was associated with **higher blood glucose** and inappropriately high insulin levels (**insulin resistance**)

Nature Reviews Endocrinology 10, 637 (2014)

Not so sweet—artificial sweeteners can cause glucose intolerance by affecting the gut microbiota

Claire Greenhill

Although NASs are not absorbed, they do contact the *gut microbiota*, which is now known to have a range of important effects on human physiology.

the past few decades, which is probably linked to changes in human nutrition. A notable change over this period is the increased use of NAS in common foods, in an effort to reduce caloric intake and normalize blood levels of glucose.

However, "the safety and efficacy of NAS use remains controversial and

of NAS in obesity, C57Bl/6 mice were fed a high-fat diet with or without saccharin.

receiving NAS and the control mice no longer had different levels of glucose intolerance, both in the lean and obese states. This result suggests that glucose intolerance induced by NAS is mediated by changes to the gut microbiota. Faecal transplantation was used to determine whether the gut microbiota had a causal

be linked to susceptibility to the metabolic syndrome," say Segal and Elinav.

fasting blood levels of glucose. Similarly to the findings in mice, 16S ribosomal RNA gene sequencing showed that participants who consumed NAS had a different microbiota composition compared with those who did not consume NAS, independently of BMI.

When seven healthy human volunteers

Cell Metabolism 20, November 4, 2014, 701-703

A Bitter Aftertaste: Unintended Effects of Artificial Sweeteners on the Gut Microbiome

dietary sugar alternative meant to stave off the risk of obesity and diabetes appear to increase disease risk due to microbial alterations

Microbial communities populate the mammalian gastrointestinal tract, closely associating with the host throughout its life span. The gut is an important site for metabolic and immune regulation, and microbial cells here substantially outnumber human cells in the entire

both human physiology and our microbial inhabitants. In parallel with modernization, rates of noncommunicable, "post-modern" diseases—such as diabetes, obesity, allergies, and asthma—have increased alarmingly (Blaser and Falkow, 2009). To combat this trend without

ulum given to the germ-free recipients, rather than to direct effects due to treatment. This approach has been employed with great success in defining how intestinal microbiota influence host metabolism under conditions of disturbance, such as comparing obese versus lean individuals

9 OCTOBER 2014 | VOL 514 | NATURE | 181-186

Artificial sweeteners induce glucose intolerance by altering the gut microbiota

"our results link NAS consumption, dysbiosis and metabolic abnormalities, thereby calling for a reassessment of massive NAS use."

ations to the intestinal microbiota. These NAS-mediated deleterious metabolic effects are abrogated by antibiotic treatment, and are fully transferrable to germ-free mice upon faecal transplantation of microbiota configurations from NAS-consuming mice, or of microbiota anaerobically incubated in the presence of NAS. We identify NAS-altered microbial metabolic pathways that are linked to host susceptibility to metabolic disease, and demonstrate similar NAS-induced dysbiosis and glucose intolerance in healthy human subjects. Collectively, our results link NAS consumption, dysbiosis and metabolic abnormalities, thereby calling for a reassessment of massive NAS usage.

Non-caloric artificial sweeteners (NAS) were introduced over a century ago as means for providing sweet taste to foods without the associated high energy content of caloric sugars. NAS consumption gained much

drinking water of lean 10-week-old C57Bl/6 mice (Extended Data Fig. 1a). Since all three commercial NAS comprise ~5% sweetener and ~95% glucose, we used as controls mice drinking only water or water supple-

European Journal of Clinical Nutrition (2012) **66**, 972

GUT bacteria and aspartame: why are we surprised?

That artificial sweeteners can modify the gut microbiome is no surprise. Even small concentrations can affect the gut biology with subsequent physiologic effects.

direct contact with the sweetener and its metabolic compounds. During obesity or periods of weight management regimes, where patients might use APM (as part of their management program), it is perhaps more crucial to have optimum bacterial community

frequently been under vigorous scientific discussion. Currently, it is still approved by the FDA, as well as the EFSA; even though on consumption, each molecule of APM releases a molecule of methanol, which metabolizes into a molecule of formaldehyde.[3] Formaldehyde (which is a highly reactive substance) is classified as a known human carcinogen, with no safe level of consumption. Therefore, it is not unexpected that very small amounts of the

E-mail: resia.pretorius@up.ac.za

REFERENCES

1 Wu GD, Chen J, Hoffmann C, Bittinger K, Chen YY, Keilbaugh SA *et al.* Linking long-term dietary patterns with gut microbial enterotypes. *Science* 2011; **334**: 105–108.
2 Gophna U. Microbiology. The guts of dietary habits. *Science* 2011; **334**: 45–46.

European Journal of Clinical Nutrition (2012) 66, 972

GUT bacteria and aspartame: why are we surprised?

(NutraSweet | Equal)

direct contact with the sweetener and its metabolic compounds. During obesity or periods of weight management regimes, where patients might use APM (as part of their management program), it is perhaps more crucial to have optimum bacterial community

Each molecule of aspartame releases a molecule of methanol which metabolizes to formaldehyde which kills gut bacteria – changing the gut microbiome.

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2 Gophna U. Microbiology. The guts of dietary habits. *Science* 2011; **334**: 45–46.

Nutrition 29 (2013) 1293–1299

Non-nutritive sweeteners: Review and update

Padmini Shankar Ph.D., R.D.[a,*], Suman Ahuja Ph.D.[b], Krishnan Sriram M.B.B.S., F.R.C.S(C), F.A.C.S.[c]

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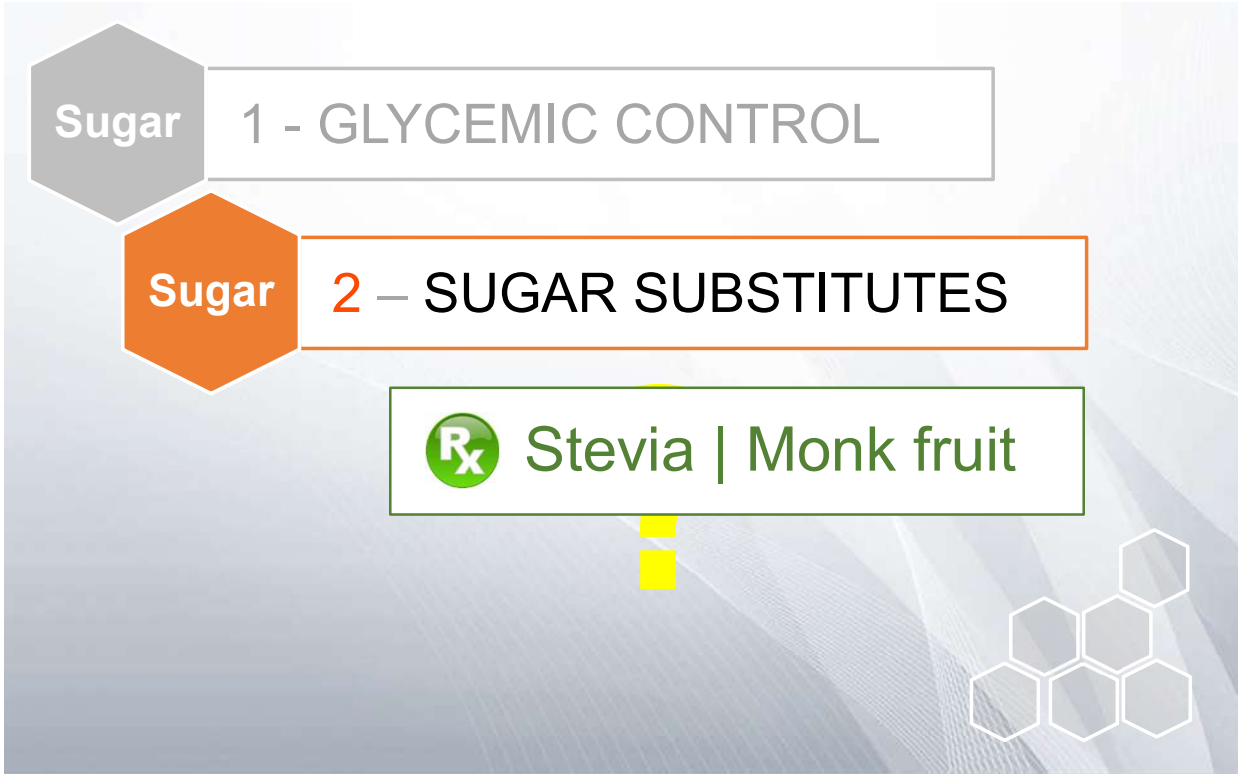
[b] *Department of Cooperative Research, Human Nutrition/Obesity Research, Lincoln University, Jefferson City, MO, USA*
[c] *Division of Surgical Critical Care, Surgical Nutrition Section and Nutrition Support Team, Stroger Hospital of Cook County, Chicago, IL, USA*

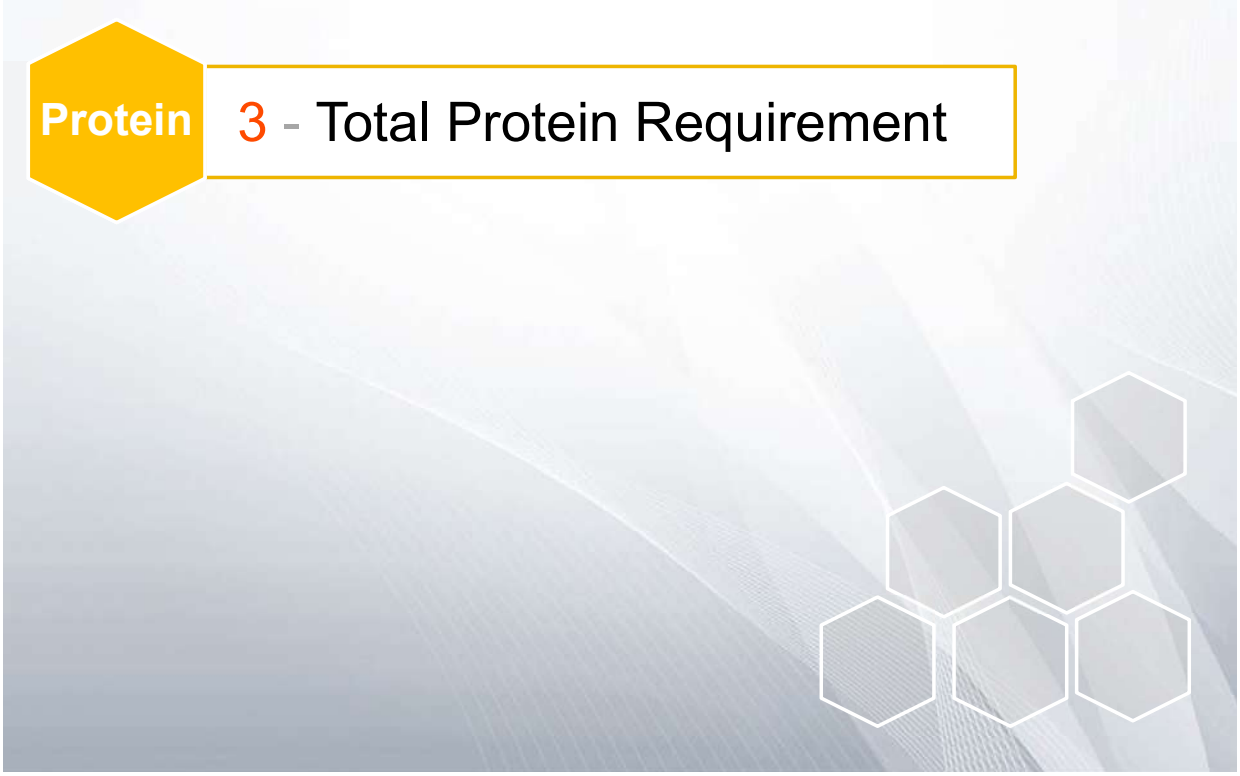
There are mixed reports about the safety of aspartame. All of the studies funded by industry vouch for its safety. In contrast, *92% of independent studies report adverse health effects*.

all ages. A systematic review of several databases and reliable websites on the internet was conducted to identify literature related to NNS. Keywords that were used individually or in combination included, but were not limited to, artificial sweeteners, non-nutritive sweeteners, non-caloric sweeteners, obesity, sugar substitutes, diabetes, and cardiometabolic indicators. The


Sugar
1 - GLYCEMIC CONTROL
Sugar
2 – SUGAR SUBSTITUTES
Stevia | Monk fruit


Nutritional Therapy: Top Ten Tenets
For Wound Care
Sugar
Vitamins
Minerals
Fat
Protein
Water

Protein 3 - Total Protein Requirement



Nutrition

Historically, clinicians used serum protein levels, including albumin and pre-albumin, to determine nutritional status. *However, current research indicates serum protein levels are affected by inflammation, renal function, hydration, and other factors*

During periods of inflammatory stress, albumin and prealbumin levels drop because they are negative acute-phase reactants.

Nutrition

- Elevated energy expenditure and *catabolism of lean body mass* are associated with chronic inflammation.
  - Acute-phase inflammatory response triggers a sequence of reactions leading to *elevated energy expenditure* and *nitrogen excretion*, which increases energy and protein requirements concurrently with anorexia and pathologically altered utilization of nutrients.

Rx 1.5-2.0 gm/kg/day IBW (100-140 gm)

Protein 3 - Total Protein Requirement

Protein 4 - Arginine (CE amino acid)

Protein 4 - Arginine (CE amino acid)

Conditionally amino acids are usually not essential, *except in times of illness and stress*; hence the term "conditionally essential" (CE). There are 8 CE amino acids.

Essential amino acids cannot be made by the body and must come from food. There are 9 essential amino acids.

Protein 4 - Arginine (CE amino acid)

- Numerous effects on wound **healing** and **immune** function.
- It is a precursor to proline – required for **collagen** synthesis
- It is a precursor for ornithine – required for NO synthesis
- Increased lymphocyte mitogensis and activity occurs.
- Multiple studies show supplemental arginine **accelerates healing** by increasing collagen deposition in wounds.

Protein 4 - Arginine (CE amino acid)

- Impaired healing with diabetes and malnutrition are associated with *low wound NO levels*.
- Inhibition of NO synthesis in wounded animals results in weaker wounds and decreased collagen synthesis.

Protein 3 - Total Protein Requirement

Protein 4 - Arginine (CE amino acid)

Protein 5 - Glutamine (CE amino acid)

Protein 5 - Glutamine (CE amino acid)

- Glutamine is the most abundant amino acid in plasma and is a primary energy source for rapidly proliferating cells.
- Glutamine supplementation **decreases infectious complications**. (Wischemeyer PE, 2001)
- Glutamine **protects against inflammatory injury** by inducing the expression of heat shock proteins - providing cellular protection from inflammation, injury, and stress. (Wischemeyer PE, 2001)
- Glutamine can modulate and **preserve gut function**, which is compromised in severe stress. (Ward E, 2009)

Protein 4 - Arginine (CE amino acid)

Protein 5 - Glutamine (CE amino acid)

Beyond daily protein requirements, specific amino acid supplements may provide benefit

Nutritional Therapy: Top Ten Tenets

For Wound Care

FAT No clear consensus

Nutritional Therapy: Top Ten Tenets

For Wound Care

Vitamins Minerals

6 - Vitamin C

Vitamins Minerals

6 - Vitamin C

RDA to prevent disease vs "optimal" RDA?

Year	RDA Edition Publication	Vitamin C RDA for healthy adult male.
1974	8th	45 mg
1980	9th	45 mg
1989	10th	60 mg
2000	DRI for Vitamin C, Vitamin E, Selenium, and Carotenoids.	90 mg

Source: Passwater Library

Vitamins Minerals

6 - Vitamin C

Vitamin C has been shown to:

- Enhance neutrophil ***migration*** in response to chemoattractants
- Enhance ***phagocytosis*** of microbes
- Stimulate reactive oxygen species (ROS) generation and ***killing*** of microbes.

(Carr AC, Nutrients 2017)

Vitamins Minerals

6 - Vitamin C

- Mice supplemented with vitamin C improved full thickness wound healing after radiation therapy along with increased collagen and fibroblast numbers. (Jagetia GC 2007)
- PRCT: Surgical patients with pressure ulcers given large doses of ascorbic acid had significant acceleration in healing. (Taylor TV 1974)

Overall, vitamin C supplementation has consistently shown benefit to wound healing.

Vitamins Minerals

6 - Vitamin C

- ✔ *Routine supplementation beyond the RDA is recommended for cigarette smokers*
- ✔ *Opinions on "optimal" vitamin C suggest doses 3-5 X the current RDA (90 mg).*

℞ 500 mg/day slow release

Vitamins Minerals

6 - Vitamin C

Vitamins Minerals

7 - Vitamin A

Vitamins Minerals

7 - Vitamin A

Vitamin A has multiple positive effects on wound healing even in non-deficient states.

- It **increases collagen** cross-linking and breaking strength.
- It increases the inflammatory response in wounds through enhanced lysosomal membrane lability, increased macrophage influx, and stimulation of collagen synthesis.
- It increases the number of monocytes and macrophages in the inflammatory phase and facilitating epithelial cell differentiation.
- Importantly, it **reverses corticosteroid-induced inhibition** of cutaneous wound healing.

Vitamins Minerals

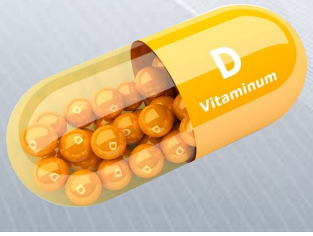
7 - Vitamin A

Rx 10,000 units for 4 weeks

Vitamins Minerals 6 - Vitamin C

Vitamins Minerals 7 - Vitamin A

Vitamins Minerals 8 - Vitamin D



Vitamins Minerals 8 - Vitamin D

- Vitamin D is more than a simple vitamin. Research has shown that vitamin D is most likely the oldest hormone
- All human cells have vitamin D receptors and the receptor effect is cell dependent
- Normal levels of serum vitamin D levels have been shown to positively affect a number of diseases such as cancer, heart disease, diabetes, hypertension, autoimmune diseases, and insufficiency fractures.

Vitamins Minerals

8 - Vitamin D

- Low levels of vitamin D associated with development of diabetic foot infections. (Yakob 2014)
- PRCT Vitamin D - Positive effects on T-cell-mediated **immunity**, **insulin secretion** and **receptor action**, cell **growth** and **healing**. (Asemi 2013)
- Vitamin D restoration of antimicrobial peptide production and improved in vitro wound-healing assays.(Gonzalez-Curiel 2014)

Effects of vitamin D supplementation on glucose metabolism, lipid concentrations, inflammation, and oxidative stress in gestational diabetes: a randomized, double-blind trial. Asemi, Z, et al. Am. J. Clin. Nutr. 2013: 98; 1425–1432.

Vitamins Minerals

8 - Vitamin D

- In rats, the topical application of vitamin D **accelerated wound healing** in a dose-dependent manner. (Tian 1995)
- PRCT: Vitamin D supplementation associated with **improved healing**. (Razzaghi 2017)
- Vitamin D promotion of endothelial and keratinocyte cell migration in a DFU model. (Trujillo 2017)

The effects of vitamin D supplementation on wound healing and metabolic status in diabetic foot ulcers: A randomized, double-blind, placebo-controlled trial. Razzaghi R, et al. J Diabetes Complications. 2017 Apr;31(4):766-772.

Vitamins Minerals

8 - Vitamin D

Dai et al. *Nutrition and Diabetes* (2019)9:8
https://doi.org/10.1038/s41387-019-0078-9

Nutrition & Diabetes

REVIEW ARTICLE Open Access

Vitamin D and diabetic foot ulcer: a systematic review and meta-analysis

Jiezhi Dai[1], Chaoyin Jiang[1], Hua Chen[1] and Yimin Chai[1]

Abstract

Seven studies (1115 patients) were analyzed. Severe vitamin D deficiency is significantly associated with ulceration. Odds Ratio 3.2

Vitamins Minerals

8 - Vitamin D

10,000 units for 4 weeks than 4,000 units there after

Vitamins Minerals 6 - Vitamin C

Vitamins Minerals 7 - Vitamin A

Vitamins Minerals 8 - Vitamin D

Vitamins Minerals 9 - Zinc

Vitamins Minerals 9 - Zinc

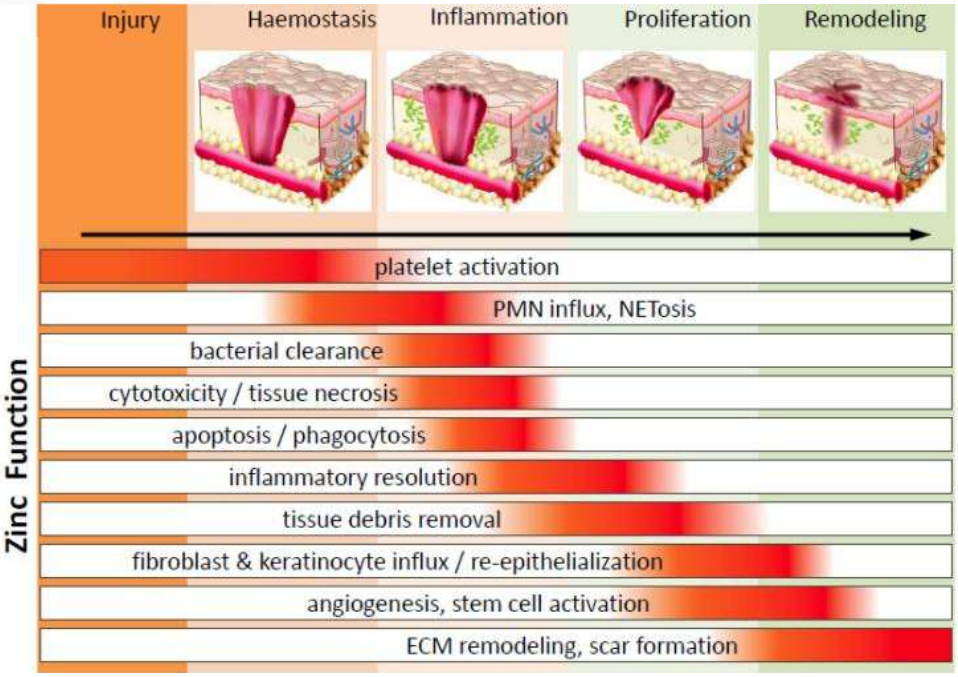
- Zinc serves as a cofactor in 3,000+ enzyme systems
- Zinc deficiency is associated with poor wound healing
- Zinc-dependent matrix metalloproteinases augment *autodebridement* and *keratinocyte migration.*
- Zinc confers resistance to epithelial apoptosis through *cytoprotection* against bacterial toxins and reactive oxygen species

*Demographic: A study of 600 nursing home residents found **50%** with low zinc levels.*

Vitamins Minerals

9 - Zinc

Summary of Zinc Functions



Vitamins Minerals

9 - Zinc

5 mg/day

Nutritional Therapy: Top Ten Tenets

For Wound Care

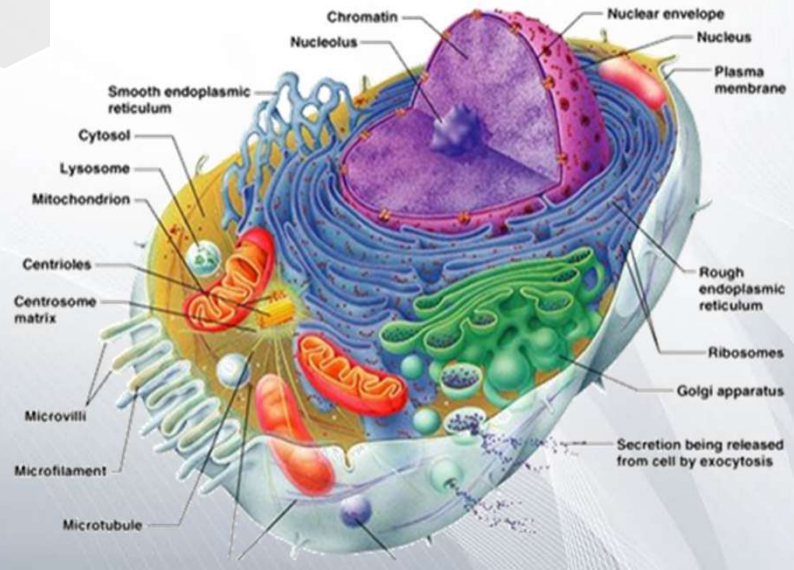
Water 10 - Hydration

30 ml/kg/day (~ 2 liters)

Increase necessary with elevated temp, vomiting, sweating, diarrhea, or heavily draining wounds.

SUMMARY

You can't build cells with antibiotics & dressings



SUMMARY

K I S Keep It Simple

SUMMARY

K I S Keep It Simple

Protein Supplement | Vitamin D | Vitamin C

NestléHealthScience

Gluten free / Lactose free

SUMMARY

K I S Keep It Simple

CE Amino Acids | CHMB

Abbott Nutrition

Arginine = Nitric Oxide
Glutamine = Collagen
CHMB* = Protein Synthesis

*calcium ß-hydroxy-ß-methylbutyrate

SUMMARY

- **Sugar** — Glycemic Control (Job 1) | Natural Sugar Substitutes
- **Protein** — 100 gm/day (Minimum) + Arginine & Glutamine
- **Vitamins A - C - D** — Vitamin A & D 10,000 IU/day | Vitamin C 500 mg/day
- **Water** — 2 liters (Qts) / day*

Nutritional Therapy: Top Ten Tenets

For Wound Care

Bob Bartlett MD

Chief Medical Offer

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ORIGINAL ARTICLE

IWJ WILEY

'Nutrition has everything to do with wound healing'—health professionals' perceptions of assessment and management of nutrition in individuals with diabetes-related foot ulceration

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Abstract

Determine how healthcare professionals perceive their role in nutrition assessment and management, and explore barriers and enablers to assessment and management of nutrition in individuals with DFU. Mixed methods including a cross-sectional online survey derived from current international guidelines and theoretical domains framework, and semi-structured interviews with conventional content analysis was performed. One hundred and ninety-one participants completed the survey, with 19 participating in interviews. Many health professionals are not confident in their ability in this area of practice, are uncertain their nutrition advice or management will be effective in assisting wound healing outcomes and are uncertain their intervention would result in adequate behaviour change by the individual with DFU. Major barriers to implementation of nutrition assessment and management were: inadequate time, lack of knowledge and lack of clinical guidance and enablers were as follows: professional development, a standardised clinical pathway and screening tool and a resource addressing wound healing and diabetes management. Nutrition assessment and management in individuals with DFU is not consistently applied. Whilst health professionals believed nutrition was important for wound healing, they lacked confidence in implementing into their practice. Further dissemination of existing guidance and implementation of education programs and resources would help overcome cited barriers.

KEYWORDS

clinician perspective, diabetic foot, dietitian, nutrition assessment, wound healing

Key Messages

- Optimal nutrition is essential for wound healing, with nutrient deficiencies associated with poorer wound healing. However, nutrition assessment and management are not routinely performed in individuals with diabetes-related foot ulcers (DFU).
- 191 health professionals from a variety of professional backgrounds completed an cross-sectional online survey with a further 19 participating in semi-structured interviews.
- Many health professionals are not confident in their ability in this area of practice, are uncertain that their nutrition advice or management will be effective in assisting with wound healing outcomes and are uncertain that their intervention would result in adequate behaviour change by the individual with DFU.
- Barriers were inadequate time, lack of knowledge and lack of clinical guidance and enablers were professional development, a standardised clinical pathway and screening tool, and a resource addressing wound healing and diabetes management.
- There were differences between professions in confidence, with allied health professionals and nurses less confident in nutrition assessment, management and making recommendations for DFU compared to dietitians. Whereas, compared to dietitians, medical professionals were less confident in nutrition assessment only and diabetes educators were less confident in making nutrition recommendations only.

1 | INTRODUCTION

Diabetes-related foot ulcerations (DFU) are estimated to affect 26.1 million individuals with diabetes worldwide per year.[1] These wounds can progress to soft tissue infection, gangrene and limb loss,[2] with individuals with DFU at a two-and-a-half-fold increased risk of mortality at 5 years compared to individuals with diabetes alone.[3] It is estimated that diabetes-related foot disease has an annual global healthcare cost of approximately 1.6 billion US dollars,[4,5] and is the leading cause of diabetes-related hospitalisation, amputation and disability burdens globally.[1,5,6] Wound chronicity is common with up to 23% of individuals with DFU remaining unhealed at 12 months,[7] which is attributed to the complex underlying aetiology including infection, vascular insufficiency, hyperglycaemia, renal insufficiency and nutrient deficiencies.[8]

Nutrition is recognised as essential for timely wound healing,[9–12] with inadequacy of energy, protein, zinc, vitamin C and vitamin D prolonging tissue repair.[13–16] Protein and zinc are imperative for white blood cell formation, function in the immune response, and are important for collagen synthesis and fibroblast proliferation.[15] Vitamin C supports wound healing as it is involved in collagen synthesis and immunomodulation involved in the proliferative and remodelling phases of wound healing.[15] Adequate vitamin D intake has demonstrated anti-inflammatory affects and supports structural integrity in wound healing.[13,15,16] Whilst numerous studies have explored nutrition interventions for DFU, the majority focus on nutrient supplementation with mixed results regarding effectiveness to support wound healing.[16–34]

Previous research confirms that individuals living with DFU frequently have poor diet quality and consequently there is a high prevalence of nutritional deficiencies, emphasising the importance of diet and nutrition as an important part of the holistic management of individuals with DFU.[35–38] Recent international guidance has been released; however, it is not currently known if this is being implemented into clinical practice.[9] Despite the known role of diet in wound healing and the prevalence of nutritional deficiencies among individuals with DFU, dietitians are not recognised as foundational health professionals within the multidisciplinary team.[39] Therefore, it is likely that non-dietitians are frequently delivering nutrition assessment and care in individuals with DFU, however details of how they practice, their perspectives on nutrition and their confidence in this area are not currently known. Additionally, it is also not currently clear how dietitians currently practice when assessing and managing individuals with DFU.

Previous research in individuals living with diabetes has shown that health professionals perceived nutrition assessment and management as part of their role, however, prioritisation of nutrition assessment and management in consults was variable.[40–42] Furthermore, a recent review of health professionals' barriers to nutrition management of adults with type 2 diabetes identified lack of time and patient non-adherence as key perceived barriers in delivering dietary care.[40] The primary aim of this study therefore, is to determine how healthcare professionals who manage individuals with DFU perceive their role in nutrition assessment and management, and secondly to explore barriers and enablers to assessment and management of nutrition in individuals with DFU.

2 | MATERIALS AND METHODS

2.1 | Study design

A mixed methods design was utilised combining a cross-sectional survey and semi-structured interviews to capture a comprehensive and holistic description of the views of a range of different health professionals. This study was approved by the University of Newcastle's Human Research Ethics Committee, Approval No. H-2022-0189.

2.1.1 | Study population

Healthcare professionals that were currently practicing or had recently practiced (in the past 6–12 months) with individuals living with DFU in Australia were eligible to participate. Health professionals needed to be registered with Australian Health Practitioner Regulation Agency (AHPRA), or if they were dietitian who were currently practicing or had recently practiced (in the past 6–12 months). All participants had to speak English, provide implied consent for the survey and electronic written informed consent for the interview. Those health professionals who were not currently practicing or had not recently practiced (in the past 6–12 months) in the care for those with DFU in Australia or were unable to speak English or were unable to provide implied or written consent were not eligible to participate.

2.1.2 | Recruitment

Participants were recruited from across Australia. Random sampling was used with a targeted recruitment strategy to optimise responses from a diverse range of health professionals involved in the care and management of DFU. Professional bodies including the Australian Podiatry Association, Wounds Australia, Primary Health, Dietitian Connection, Australia Diabetes Educator Association, Australian Medical Publishing Corporation and Dietitians Australia assisted with invitation dissemination through their respective email or online newsletters. The research team also utilised snowballing by disseminating the survey invitation in their professional networks. At the end of the survey, participants were invited to participate in a semi-structured interview to further discuss the topic to assist health professionals involved in the assessment and management of DFU.

3 | QUANTITATIVE COMPONENT

3.1 | Data collection/gathering

The survey was developed and disseminated using REDCap.[43,44] Survey questions were developed through conducting a literature review of studies exploring nutrition assessment and management, utilising the theoretical domains framework and qualitative research in venous leg ulcers and informed by current guidelines.[9,40,41,45,46]

The survey consisted of 36 closed questions and two open-ended questions aiming to elicit current practice relating to nutrition assessment and management in individuals with DFU. Dietitians and diabetes educators were asked an additional four closed questions and one open-ended question. Research questions were peer-reviewed, piloted and refined within the research team. The draft survey questionnaire was pilot tested by a statistician and on a small number of health professionals ($n = 5$) and refined by utilising feedback given. Participants were screened for eligibility, using the pre-defined eligibility criteria. Eligible participants then completed basic demographic data indicating: age, gender, health professional type, years of clinical experience, duration of experience working with individuals with DFU, how frequently they work with individuals with DFU, number of individuals with DFU they see per day/week, registration body, postcode of employment, type of employment and employment setting. To gain a range of perspectives, health professionals from a variety of disciplines which included rural and urban settings were encouraged to participate. The outcomes of interest for the current study included: (1) experience in years, (2) current practice in assessment and management of diet of those living with a DFU, (3) barriers and enablers to assessment and management of DFU, (4) dietitian and diabetes educator-specific variables including nutrient requirements and malnutrition screening and (5) confidence in nutrition assessment and management of DFU. A combination of multi-check multiple choice and single answer multiple choice questions

were utilised in the survey. A Likert scale was utilised to determine health professionals' confidence in adherence of individual with DFU to nutrition advice, with one indicating not confident and five indicating very confident. If the option, 'other' was chosen, an open text box was utilised for participants to elaborate.

3.2 | Statistical analysis

Analyses were performed using STATA for Windows (BE 17.0). The majority of question data was categorical and therefore displayed as descriptive statistics including frequencies and percentages. Normality was assessed utilising a histogram, Shapiro–Wilk test and the Skewness and Kurtosis test. Data were reported as mean ± SD or median (IQR) means and standard deviations or the medians and interquartile ranges depending on the distribution of the data. Questions that had 'other' as an option and greater than five participants provided the same answer were deemed important and added to the results. The number of participants who did not answer the question or were not asked a particular question is also displayed. Numerous questions allowed multiple answers therefore percentages do not always add up to 100%. An ordinal logistic regression model was utilised to determine if any factors such as work setting, years of experience, health professional type, sex or rurality influence confidence in nutrition assessment and management of those living with DFU.

4 | QUALITATIVE COMPONENT

4.1 | Setting and study participants

In total, 71 out of 191 healthcare professionals from the survey were willing to participate in an interview to further explore their perspectives. To gain a range of perspectives, health professionals from a variety of disciplines, and from rural settings as well as urban settings were invited to participate. Participants were recruited until researchers felt data saturation was achieved and no further interviews provided new eccentric insights or meanings. Researchers deemed data saturation was achieved at 19 participants.

4.2 | Data collection

One researcher (HD), a dietitian, conducted semi-structured interviews with health professionals who consented to participating. Interviews were conducted and recorded on Zoom for convenience as participants were recruited from across Australia. Interview questions were developed by conducting a literature review of research exploring diet assessment and management, qualitative research in venous leg ulcers and the theoretical domain framework.[40,41,45,46] Interview questions were peer-reviewed, piloted and refined within the research team with a range of open and closed questions ($n = 17$) included in the final script (Appendix A). Probes were open-ended and unique to the participant rather than pre-existing theory, aligning with inductive conventional content analysis.[47] The opening question, 'What started your interest in wounds?' was used to establish rapport between the researcher and participant before addressing the main questions. Basic demographic data collected during interviews was consistent with the survey. These data were collected to provide adequate sample description.

4.3 | Data analysis

Once transcribed by a single researcher (HD), the interviews were imported into NVivo® software (QSR International ©) for analysis. Two researchers (HD & PT) utilised an inductive conventional content analysis for data analysis, with both undergoing multiple readings of the dataset to immerse themselves in the data.[47] Both researchers underwent coding exact words/perspectives from the interviews, noting their first impressions/thoughts, labelling codes, creating patterns of meaning, potential categories, developing definitions for each category and refining these to create final categories which address the research aims.[47] Due to the paucity of scientific literature in this topic, an inductive conventional content analysis approach was utilised where knowledge is generated from participants' unique perspectives.[47] Two researchers (HD & PT) utilised their different health professional backgrounds during qualitative data analysis. All researchers involved in this study are health professionals including three dietitians and a podiatrist with experience of working with people with diabetes. All researchers reviewed the codes and themes and provided feedback. To enhance trustworthiness and credibility during data analysis, peer debriefing, prolonged engagement with the data and triangulation occurred within the research team.

5 | RESULTS

5.1 | Quantitative study results

5.1.1 | Participant characteristics

A total of 191 participants completed the survey and were included in the analysis, with a median age of 38 years

TABLE 1 Survey participant demographics ($n = 191$).

Characteristic	Response ($n = 191$)	
States	New South Wales	88 (46.8)
	Queensland	22 (11.7)
	South Australia	6 (3.2)
	Western Australia	22 (11.7)
	Victoria	42 (22.3)
	Tasmania	7 (3.7)
	Northern territory	0 (0.0)
	Australian capital territory	1 (0.5)
	Missing	3 (1.6)
Modified Monash Model geographical classification	MM1 (Metropolitan)	115 (61.2)
	MM2 (Regional centres)	28 (14.9)
	MM3 (Large rural towns)	7 (3.7)
	MM4 (Medium rural towns)	4 (2.1)
	MM5 (Small rural towns)	27 (14.4)
	MM6 (Remote communities)	2 (1.1)
	MM7 (Very remote communities)	5 (2.7)
	Missing	3 (1.6)
Health professional type[a]	Endocrinologist	8 (4.2)
	General practitioner	2 (1.1)
	Podiatrist	89 (46.6)
	Dietitian	41 (21.5)
	Diabetes educator	21 (11.0)
	Registered nurse	15 (7.9)
	Clinical nurse consultant	6 (3.1)
	Clinical nurse specialist	3 (1.6)
	Nurse practitioner	5 (2.6)
	Other	9 (4.7)
Work setting[a]	Hospital (inpatient)	79 (41.4)
	Hospital (outpatient)	107 (56.0)
	Community-based	76 (39.8)
	Private practice	30 (15.7)
	Individual practice/sole practitioner	12 (6.3)
	Aged care	5 (2.6)
	Other	6 (3.1)

Abbreviation: IQR, Interquartile range.
[a]Multiple options were allowed.

(IQR 18), 81.7% female, and a median of 14 years (IQR 16) of practice. Most participants were podiatrists (47%, $n = 89$) or dietitians (22%, $n = 41$), from metropolitan areas (61%, $n = 115$) and working in outpatient settings (56%, $n = 107$). Participant characteristics for the survey are presented in Table 1.

5.1.2 | Clinical experience

Approximately 42% ($n = 81$) of respondents reported liaising with the multidisciplinary team on a daily basis regarding care of individuals with DFU (Supplementary Table 1). Frequency of referral to a dietitian by non-

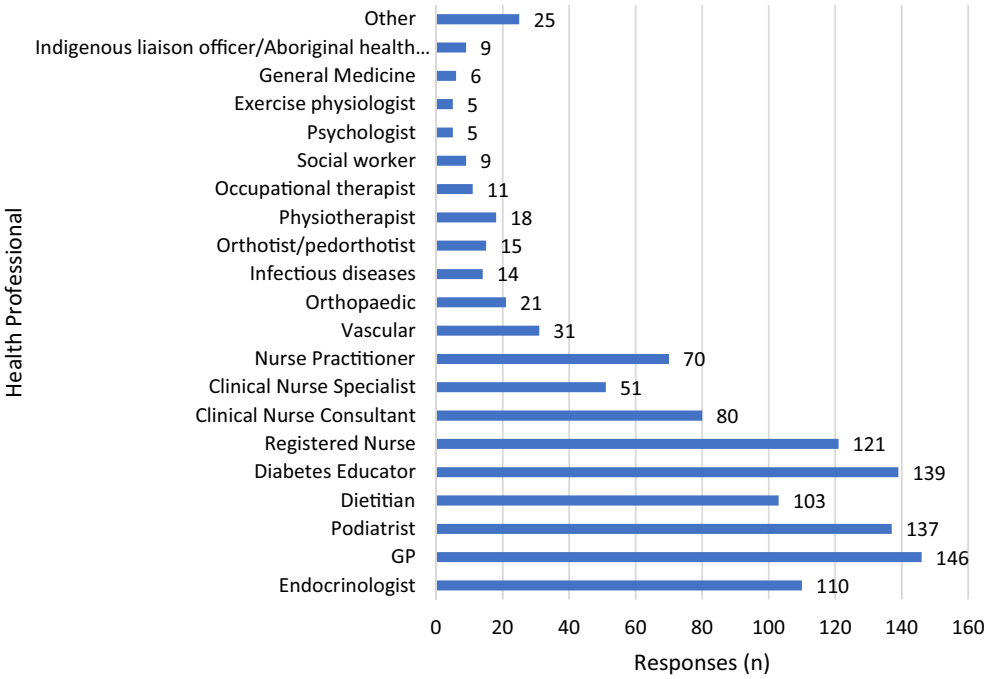

FIGURE 1 A clustered bar graph demonstrating what health professionals' participants liaise with, $n = 191$. GP, general practitioner.

dietitians was highly variable, with the majority (72%, $n = 108$) reporting they refer to dietitians between once a month to once a year or never. The majority of respondents (80%, $n = 153$) worked in multidisciplinary teams, with approximately two-thirds of all health professionals reporting they regularly liaised with registered nurses, diabetes educators, podiatrists and endocrinologists, whilst only half reported liaising with dietitians (Figure 1).

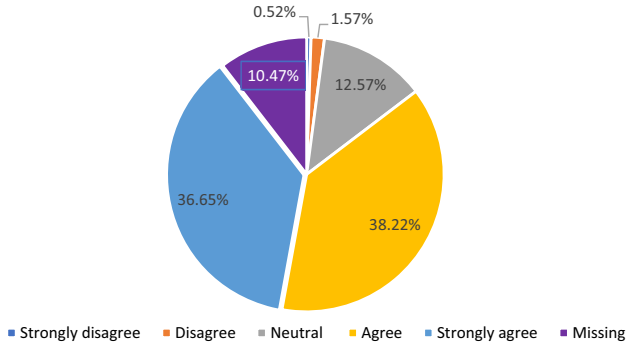

FIGURE 2 A pie chart demonstrating participants level of agreement with the statement, 'There is evidence relating to clinical outcomes in dietary management of diabetes-related foot ulceration'.

5.1.3 | Nutrition assessment and management

Results for questions relating to nutrition assessment and management of individuals with DFU are summarised in Supplementary Table 2. Respondents acknowledged that diet is important for wound healing in DFU (87%, $n = 167$), however, fewer (75%, $n = 143$) agreed there is evidence relating to clinical outcomes in nutrition management of DFU (Figure 2). Of those who answered, half were not confident that individuals with DFU would adhere to dietary advice provided (Supplementary Table 2). One quarter reported that they never conduct nutrition assessment, with diet history the most frequently reported method (45%, $n = 86$) (Supplementary Table 2).

When asked about the 'Nutrition Interventions in Adults with Diabetes Foot Ulcers Expert Consensus and Guidance', 73% ($n = 140$) were unaware and 81% ($n = 154$) did not use the expert consensus and guidance document. Whilst 16% ($n = 31$) of respondents were aware of the guidance statement, only half ($n = 15$) use the guidelines in their practice (Supplementary Table 2).

When nutrition management was performed it most commonly involved education specific to DFU (34%, $n = 65$), education specific to diabetes (43%, $n = 82$) or education on nutrition in general (37%, $n = 70$). Types of nutrition management reported by health professionals are presented in Figure 3.

5.1.4 | Barriers and enablers

Results for questions using theoretical domain framework to guide questioning regarding barriers and

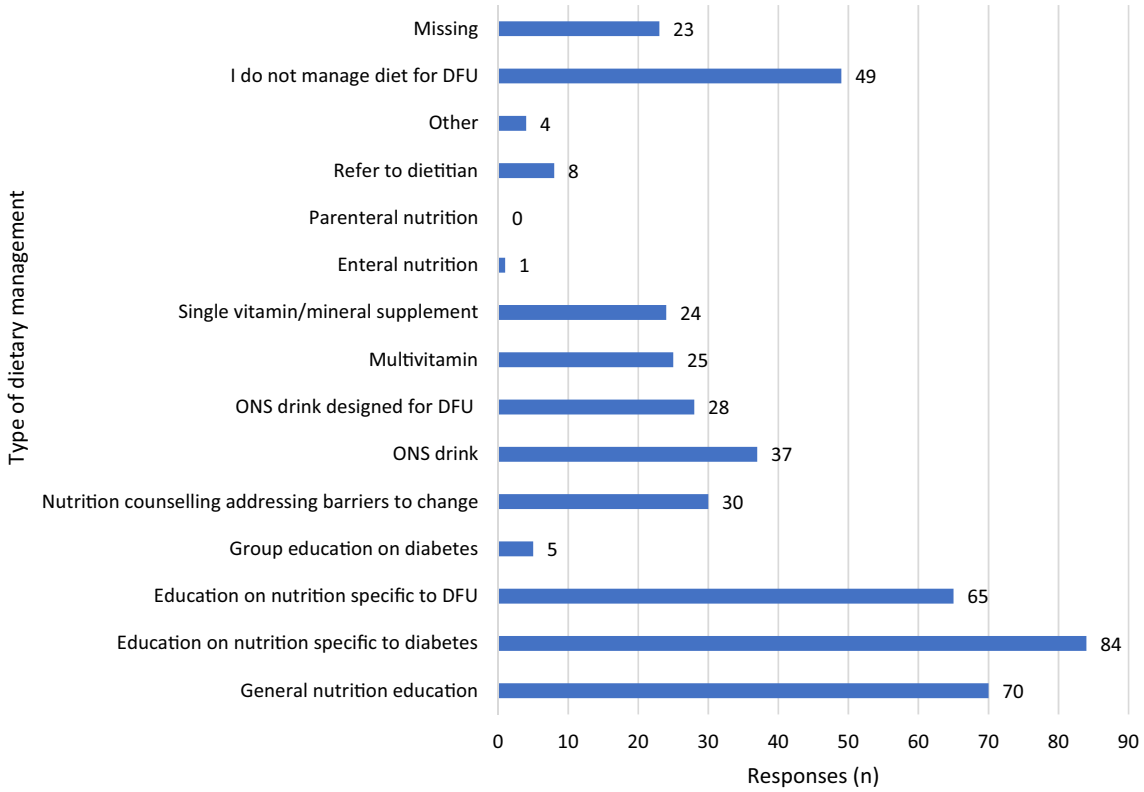

FIGURE 3 A clustered bar graph indicating the type of dietary management implemented by participants, $n = 191$. DFU, diabetes-related foot ulceration; ONS, oral nutrition supplements.

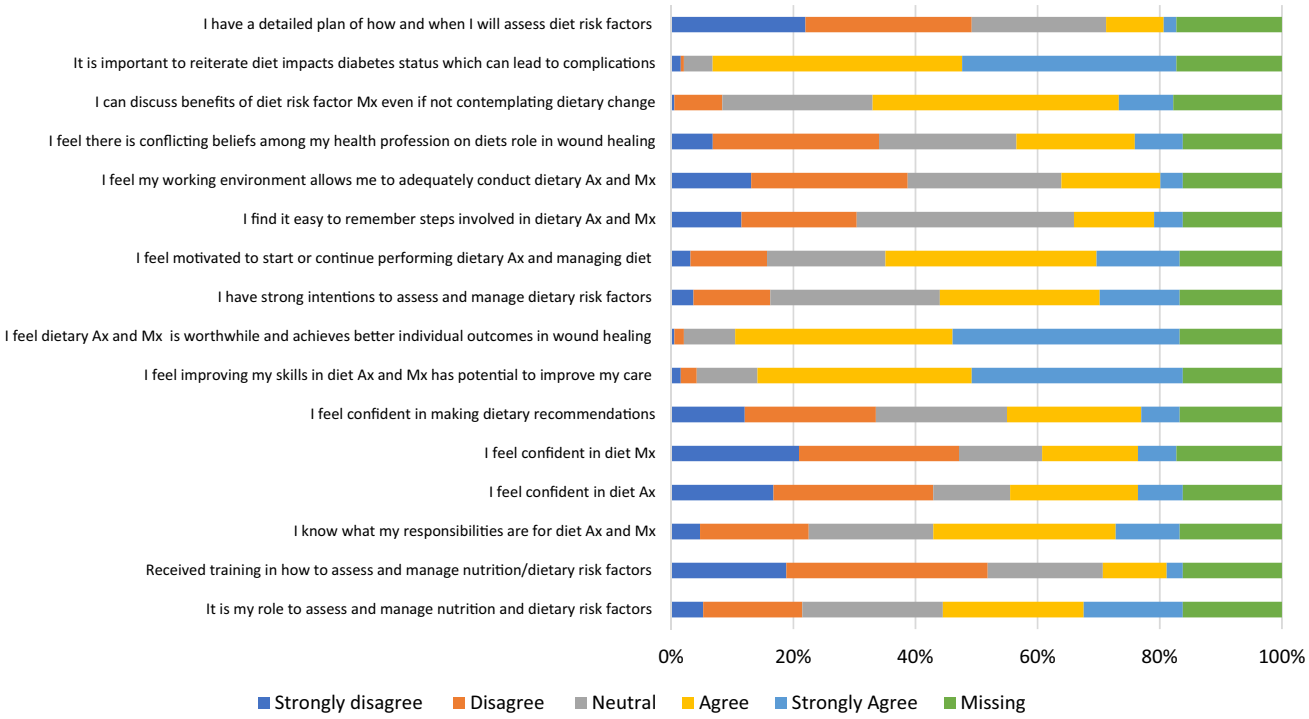

FIGURE 4 A stacked bar graph demonstrating participants' agreement with statements about nutrition assessment and management in relation to each domain within the theoretical domain framework, $n = 191$. Ax, assessment; Mx, management.

enablers of nutrition assessment and management are summarised in Figure 4. Whilst 39% ($n = 75$) agreed it was their role to assess and manage diet and 40% ($n = 77$) agreed they knew their responsibilities in this area, only 13% ($n = 25$) reported receiving training in this area. Greater than two-thirds of health professionals felt improving their skills in nutrition assessment and management had the potential to improve care ($n = 133$), and nutrition assessment and management is worthwhile and achieves better individual outcomes for wound healing ($n = 139$). Yet, the majority reported that: (1) it would not be easy to remember the steps involved in nutrition assessment and management (66%, $n = 126$), (2) their work environment does not allow them to adequately assess dietary intake, nutritional status and then provide medical nutrition therapy (64%, $n = 122$) and (3) they do not have a detailed plan of how and when to assess nutritional status and diet-related risk factors (71%, $n = 136$).

Health professionals' barriers to conducting nutrition assessments and supporting individuals with DFU to manage their dietary intake were explored. Approximately half the respondents reported time (52%, $n = 100$) and lack of knowledge (46%, $n = 88$), with one-quarter to one-third indicating staff shortages (29%, $n = 55$), lack of experience (34%, $n = 65$) and feeling individuals with DFU would not comply (26%, $n = 49$) as barriers. Ten participants reported they prefer to refer to a dietitian (5.2%), 15 reported it was not their area of expertise or they were not trained in this area (7.9%) and 21 did not respond to the question (11%).

5.1.5 | Dietitian and diabetes educators

Dietitians and diabetes educators were asked additional questions due to their scope of practice, with results presented in Supplementary Table 3. Forty-six percent of dietitians and diabetes educators reported their nutrition assessment and management for those with DFU differed from those with diabetes but without a wound ($n = 26$), with protein intake being the primary additional focus (80.8%, $n = 21$). Approximately half of respondents reported screening for malnutrition in patients with DFU ($n = 27$).

5.1.6 | Health professionals' confidence in nutrition assessment and management

The results from the ordinal logistic regression for participants' confidence in conducting nutrition assessment, nutrition management and making dietary recommendations are presented in Supplementary Tables 4–6. Compared to dietitians, allied health (OR 0.10, 95%CI 0.05–0.21), medical staff (OR 0.28, 95% CI 0.08–0.96) and nurses (OR 0.24, 95% CI 0.09–0.63) were significantly less confident in nutrition assessment. Furthermore, allied health (OR 0.09, 95%CI 0.04–0.19) and nurses (OR 0.26, 95%CI 0.10–0.68) were significantly less confident than dietitians in nutrition management. Allied health (OR 0.14, 95%CI 0.07–0.29), nurses (OR 0.24, 95%CI 0.09–0.63) and diabetes educators (OR 0.28, 95%CI 0.11–0.75) were significantly less confident in making recommendations for individuals living with DFU than dietitians.

5.1.7 | Professional development

Most participants indicated they would benefit from professional development specific to assessment and management of diet for individuals with DFU, with 79% ($n = 151$) reporting yes. However, health professionals did not seem to have a strong preference for the type of professional development with the top three options reported being a webinar (66%, $n = 126$), written resource (56%, $n = 107$) and a course (52%, $n = 100$). The most preferred delivery method for professional development was online (68%, $n = 129$), with 44% ($n = 83$) of participants suggesting face-to-face delivery as appropriate. Additionally, the health professionals indicated 1-h professional development (47%, $n = 90$) or a half-day professional development (43%, $n = 82$) was most preferred.

5.2 | Qualitative study results

5.2.1 | Participant characteristics

Nineteen participants completed semi-structured interviews, with a median age of 35 years (SD 12) and the median years of experience working with DFU being 9 years (SD 12). Participants were predominantly females (74%, $n = 14$) and nurses (37%, $n = 7$). Other participant characteristics for the interviews are presented in Supplementary Table 7. The duration of interviews depended on participant engagement with the interviewer, ranging from 10:06 to 49:40 min.

5.2.2 | Themes

Two themes were generated, 'Nutrition is underutilised' and 'Love at first wound'.

'Nutrition is underutilised'

This theme explores the variety of barriers contributing to the lack of nutrition assessment and management

being completed by health professionals in patients with DFU. There was an overall consensus that dietary assessment and management is not consistently implemented—'nutrition is underutilised' (P5, clinical nurse consultant). The discussion of barriers was broad, including aspects such as lack of time, rurality and the impact on food agency and access to specialist care, lack of evidence and expertise, professional roles and responsibilities and patient barriers in engaging with dietitians and a lack of understanding that diet is part of wound healing.

Participants frequently expressed nutrition assessment and management were not priorities when they see individuals with a DFU, due to time constraints, glycaemic control requiring precedence, as well as a reported lack of expertise, awareness, interest and evidence supporting the role of diet and wound healing.

> *'So I usually see them in the context of a booked clinic and typically I will not explore the diet until I see them for the third time. So usually the first time around I'm looking at them, I'm looking at how best I can, what's the fastest gain I can get in terms of glycaemic control, often that's titration of their treatment', P12, endocrinologist advanced trainee.*

Some participants voiced concerns about the extent of rurality impacting ability for those living with DFU to access timely nutrition intervention as well as food agency (ability to obtain and prepare food within their social, physical and economic environment)[48] affecting their uptake of dietary advice.

> *'Um other things I find can be difficult is um just that socioeconomic status and availability to food and nut-, good food and nutrition and um, kind of health literacy or just knowing which foods um are good and and less healthy as well', P8, dietitian.*

Participants felt 'uncomfortable talking about' (P12, endocrinologist advanced trainee) nutrition with their patients stemming from the paucity of strong evidence and minimal guidance in regard to nutrition assessment and management, and consequently some reported they were going by traditional dietetic knowledge they had.

> *'Um, not having um a clear knowledge of um the evidence um, I'm just going by old knowledge that I have, not having the time to look into things, um not being aware of um current guidelines and current evidence', P6, dietitian.*

Participants expressed that perceived paucity of evidence and guidance contributed to subsequent lack of expertise in conducting nutrition assessment and management in this population, with some participants articulating they are, 'just winging it' (P6, dietitian). Conversely, despite the lack of research evidence and guidance, some health professionals reported providing advice they were not confident in and subsequent potential misinformation. Dietitians were encouraging discussion with dietitians who specialised in the area.

> *'I think a lot of dietitians get intimidated with areas they don't know... A lot a lot a a lot of my friends are dietitians, you'll ask them about a specific wound and they'll go, "Well the guidelines". I'm like, "no, what's your experience", and they're like, "Well you know I don't know that much. I I I'm not like you probably better off asking a hospital one". Again, so it's sort of, you know that that subspecialty of some specialty factor', P13, podiatrist.*

An additional barrier contributing to the lack of nutrition intervention in this population was how health professionals perceived their role in nutrition assessment and management. Some health professional participants proposed it is not their responsibility if they had access to a dietitian and therefore did not feel they needed to consider wound management through a nutrition lens.

> *'And I think, because we do have our dietitian in-house generally, that we sort of palm that off to her to be honest. We're like "you're the expert" and we'll leave that with you', P7, podiatrist.*

Conversely, those from a rural setting reported a lack of access to dietetics, and consequently, they were required to wear many health professional 'hats' or roles in this population care.

> *And I think if you work rurally, I think you're probably more interested in attending these events because you have to wear many hats and I sort of find that, like when I'm in the high-risk foot clinic I'm... I'm a podiatrist, and I'm a podiatrist primarily, but when I'm in my community health role, I'm like a lot of different things. And you know, I think having a little bit more knowledge would go along way. P7.*

Participants frequently reported a lack of clinical interest in nutrition for wound healing, leading to a subsequent lack of motivation to engage or support those living with DFU from a nutrition perspective. Moreover, some dietitians expressed their lack of interest was derived from previous experience of no apparent benefit in wound healing outcomes as well as previous apprehension towards dietitians from this population, and individuals with DFU not making the suggested dietary change as recommended. Other non-dietitian health professionals outlined that dietitians were unwilling to see those living with a DFU, and rather the multidisciplinary team would prefer to utilise medication or supplementation as first-line therapy.

> *'Um despite [laughs], despite my lack of motivation um in these um... with the dietitian's role within this, I do still believe that a dietitian does have an important role within the multidisciplinary team for high-risk foot clinic. Um it can be a little bit um... well glass half empty kind of feeling, like the satisfaction in in being able to do your job in the clinic is is very very low, um but you do get one in every I don't know I'm just making up stats here, one in 10 or something that does uptake on the information um and you do see an improvement in the wound um... it it it- look, it's one person out of 10 that you've had success with. So yes, I I do think there's still a role, it's just really difficult when the other 9 are not particularly motivated', P10, dietitian.*

Participants commonly expressed that individuals with DFU commonly expressed feeling judged by dietitians, another barrier to the patient accessing nutritional support for their wound healing.

> *'Um sometimes I guess you know, getting people to see a dietitian can be a challenge. Um we're not, we're historically have not been seen as um, we have I imagine we've been seen as bit of a judgmental health professional. Um so a lot of the first, well getting them to the first appointment is a lot of rapport building', P15, dietitian.*

Furthermore, non-dietitian health professionals highlighted that they were not aware of their role in nutrition assessment and management of DFU and consequently did not conduct nutrition assessment or management.

> *'Um a little, I only recently learnt about how much it can actually affect it. So it's something that's still pretty new to me, but I always look out for it a lot more now', P16, diabetes educator.*

Health professionals also perceived patients lacked an understanding of the role of diet in wound healing.

> *'It's always comes a surprise so when I start talking about nutrition and the role it has in wound healing, they're a bit like, oh, like, why didn't anyone tell me this before?', P8, dietitian.*

'Love at first wound'

This theme describes the overwhelming passion to help these individuals with DFU expressed by many of the health professionals in the current study. The included health professionals come from a variety of backgrounds, clinical experience and geographical locations, yet shared a common goal of improving wound healing and quality of life for individuals with DFU.

> *'Whether people believe that that... nutrition is a very important part of wound healing... it's incredibly evident, that nutrition has got everything to do with wound healing', P1, podiatrist.*

> *'What really interested me was the immediacy of it, in the sense that if you don't fix up a patients wound, it could potentially be lethal. So um, that really appealed to me, as well as the complexities and the nuances, whether it's diet, whether it's vascularity, whether it's that wound dressing selection... So, I'm I've pretty much just been interested since day one yeah... Love at first wound.', P13, podiatrist.*

Whilst unawareness was identified as inhibiting health professional application of nutrition assessment and management, some participants felt optimistic and suggested that increasing health professional and patient awareness of the role of nutrition in wound healing would improve clinical uptake of nutrition intervention in their consultations.

> *'So I think make it more known to people um and the research that you you're doing will help as well. But if people be like, "oh! it it actually makes a big difference", and I think... it'll be cost effective too and people will like need to be more I guess um intuitive towards*

it, this area', P3, endocrinologist advanced trainee.

Participants also voiced the need for a clinical pathway to streamline nutrition assessment and management of those with DFU.

'Um I think it needs to kind of come from a holistic supported team, but particularly from the powers above', P2, clinical nurse consultant and diabetes educator.

Furthermore, health professionals described the need for a standardised yet simplified nutrition screening and assessment tool for non-dietitians.

'I don't know what dietitians use, but there should be more of is a simplified version of of of a validated tool that people should be able to use, and then the dietitian then teach the nursing staff to do it', P17, nurse practitioner.

In relation to patient education, most participants discussed the need for a wound healing resource that considers diabetes management due to the absence of this style of resource in the contemporary context. Perspectives on what the resource should encapsulate was quite unanimous, with most suggesting a predominantly visual resource with a plain text aspect as most appropriate for all individuals living with DFU from various backgrounds.

'So having a really good visual tool I feel like would be really helpful um because sometimes tryna like explain it to someone who's like, you know English isn't their first language or something else, it can be quite tricky, or someone who has um social um... issues... So having some um very simplified resources would be really great', P14, dietitian.

Another commonly reported enabler to increased nutrition assessment and management for those with DFU was the inclusion of a dietitian in the high-risk foot clinic, with some suggesting increased presence of a dietitian in this setting would increase awareness and subsequent application of nutrition intervention for DFU.

'Um and I think it might- and like you know, having someone that comes around to clinic or um is is present at those appointments so like for clinic for example, having someone present, just keeps it front of mind for people like, oh, yeah, there's a dietitian here because foods important for foot wounds, do you know what I mean? So I think um yeah, having having someone visually around', P2, clinical nurse consultant and diabetes educator.

Whilst all participants expressed being interested in attending professional development in relation to nutrition and wound healing, participants discussed the professional development content would need to be designed and individualised to the different health professional types and the role they can play in this population's nutrition-related care.

Most agreed that health professionals working with this population need education, to not just increase awareness but also implementation of nutrition assessment and management for those with DFU. Participants concluded a concise presentation tailored to the role that each health professional can play in this population's nutrition-related care complimented by a case study for a practical sense was most beneficial.

'The communication method that I'd prefer is more of a presentation style but once again brief, um particularly- depending on the clinician you're presenting to. Dietitians might be happy to go into all the biochem but um I'd say from a DE perspective, we just want to know why it's important and what we have to do', P2, clinical nurse consultant and diabetes educator.

Despite nutrition management of DFU being the main focus, some participants expressed the need for nutrition to be embedded in prevention of DFU.

'And then they sort of bring them in at the end, you know, sort of like, "well, what do we do now?" and they're like, "Well, why didn't you call me like 6 months ago or 6 years ago?". So that could be an idea as well', P13, podiatrist.

Whilst most felt dietitian presence and nutritional information is imperative for this population, most also expressed the need for the advice to be individualised to the client's personal context with consistent messaging from all health professionals involved in their care.

'Certainly, being on the same page as well, um having that united in front that it's not just the dietitian', P10, dietitian.

'We shouldn't look at a wound as a hole in a person, but look at the whole person, because

then that includes their nutrition, hydration and um, promoting wound healing', P17, nurse practitioner.

6 | DISCUSSION

This study determined health professionals' perceptions of their role in implementing nutrition assessment and management for individuals with a DFU, and explored the current barriers and enablers to implementing nutrition assessment and management in practice. The results of the current study suggest that many health professionals are not confident in their ability in this area of practice, are uncertain that their nutrition advice or management will be effective in assisting with wound healing outcomes, and are uncertain that their intervention would result in adequate behaviour change by the individual with DFU. Whilst most health professionals recognised diet and nutrition as important for wound healing in DFU, health professionals frequently reported a lack of time and knowledge, lack of adequate referral pathways and a lack of general interest in conducting nutrition assessment and providing dietary management. Health professionals expressed an interest in undertaking further professional development in this area to enhance their practice and cited that enablers included professional development, a standardised clinical pathway and screening tool and a resource addressing wound healing and diabetes management collectively.

Lack of time and knowledge were key barriers identified by health professionals for conducting nutrition assessment and providing dietary management. This finding is consistent with previous research in individuals with type 2 diabetes, with multiple studies also confirming that time and lack of expertise can inhibit care in this population.[49,50] The lack of knowledge identified in the current study was also the perception of a lack of clinical guidance and high-level evidence for the effectiveness of nutrition intervention in DFU. This perception was despite the published 'Nutrition Interventions in Adults with Diabetes Foot Ulcers Expert Consensus and Guidance'.[9] More than half of health professionals surveyed were unaware of this guidance document. Additionally, only half of those aware of the guidelines subsequently utilised them in their practice. This highlights the need to increase health professional awareness of the evidence and clinical guidance which exists to improve implementation of nutrition assessment and management for patients with DFU. The perception of a lack of evidence to support practice in this area may stem from current international guidelines not recommending nutritional supplementation in individuals with DFU.[39] Supplementation may benefit wound healing outcomes in DFU,[9,16,17,20,23,24,27–29,31,34] however, there is significant heterogeneity in completed studies and a lack of high-quality level 1 evidence to support a guideline recommendation. However, nutrition assessment and management encompasses more than supplementation alone, and medical nutrition therapy potentially has a significant role to play, yet there is also little evidence to date to support this. Therefore, more high-quality research would be beneficial in exploring the effectiveness of medical nutrition therapy in this population who are at high risk of adverse diet-related outcomes, including poor wound healing and glycaemic management.

Dietitians who are responsible for the delivery of medical nutrition therapy did not feel confident that individuals with DFU would adhere to dietary advice and make the required behaviour change. This perception is highly suggestive that there is health professional's stigma associated with individuals with DFU being generally considered non-adherent. This finding is consistent with previous studies which have similarly found health professionals make value judgements, have personal biases and generally stigmatise people with diabetes.[51–53] A previous qualitative study in high-risk podiatrists highlighted that many podiatrists were found to stereotype patients with DFU as non-compliant.[52] Another qualitative study reported that diabetes patients felt judgemental and stigmatising attitudes from their podiatrists and dietitians, which led to behaviour such as manipulating their blood glucose readings or avoiding testing when they perceived results would be above recommended targets.[51] This subsequently resulted in reduced patient engagement with these key services.[54] Other previous research has identified health professionals have prejudice relating to patients with type 2 diabetes not adhering to dietary advice, as well as obesity-related stigma.[55] Diabetes stigma has also been demonstrated in non-diabetes-specific physicians.[56] These previous studies, in conjunction with the findings of the current study, suggest that it is likely that stigma and prejudicial views held by health professionals are also likely impacting on the dietary management of individuals with DFU. Health professionals should have greater awareness of this and develop strategies to overcome this in order to ensure better patient engagement with their health care, including medical nutrition therapy.[56]

Medical nutrition therapy consists of both assessment and management, in a person-centred fashion. The results of this study demonstrated that doctors were more confident to give nutrition advice and make recommendations, but less confident to perform nutrition assessment. This is consistent with previous studies which acknowledge that doctors perceive that nutrition plays an important part in health, and that providing nutrition advice is part of their role.[57] However, the advice given by doctors is likely to be insufficiently detailed and not

able to be sustained in order to result in a meaningful change.[58] Furthermore, advice and management should be based on an objective nutrition assessment, which is imperative to providing personalised medical nutrition therapy.[59] Previous research concluded individuals with DFU are seeking personalised dietetic support that considers their capabilities, opportunities and motivations.[60] A potential contributing factor to the lack of confidence in nutrition assessment by doctors may relate to a lack of easily applied screening tools that are suited to medical and other health practitioners. An additional major barrier to referring individuals with DFU for nutritional support for wound healing was the patient perception of dietitians as judgemental, aligning with previous research exploring the perceptions of individuals with DFU.[60] There is a need to overcome the negative stereotype of dietitians as authoritarian figures, but rather as enablers of behaviour change and leaders in positive dietary behaviours. Overcoming these barriers is required to facilitate improved referral pathways and nutrition support for individuals with DFU.

Participants were not certain when they should refer a patient with a DFU to a dietitian and whether the referral would be deemed appropriate. Referral rates from doctors to dietitians for eligible conditions in Australia has been shown to be very low (0.26%),[61] and may be a result of doctors' perceptions of dietary strategies as adjunct therapies, despite being classified as first-line therapy for some conditions such as type 2 diabetes.[62] There is an urgent need for individuals with DFU to see a dietitian, as body mass index (BMI) in the overweight/obese classes[38,60] and concurrent malnutrition are highly prevalent.[63] Only half of dietitians and diabetes educators in the current study completed malnutrition screening assessment in those with DFU, emphasising the need to increase awareness of the importance of malnutrition screening for all patients in this population, and the need for this to be a standard step in triage. This is consistent with a recent study which reported the majority of individuals who were overweight or living with obesity and malnutrition were not identified on the Malnutrition Universal Screening Tool, emphasising the underestimation of malnutrition risk in this population and the need for increased awareness of malnutrition in those with a higher BMI.[64] Therefore, a screening tool determining the need for dietitian referral in this population, paired with a clinical pathway with referral to a dietitian of all patients with active DFU is warranted.

The majority of health professionals indicated professional development in this area would increase their confidence and allow them to make more impact in this population. Health professionals preferred professional development to be offered online with a duration of 1 h up to a half-day, with no preference in regard to the type of professional development (webinar, written resource or course). Further exploration of this topic showed that health professionals had a preference for education to be personalised to their discipline. Participants showed preference for case studies as part of their professional development. A recent review exploring case-based learning in medical and other health professionals suggested case-based learning produced a deeper understanding of implementing theory in practice.[65] Therefore, the development of profession specific, case-based learning resource could be developed to improve health professionals' knowledge and confidence in nutrition management of individuals with DFU.

6.1 | Strengths and limitations

To our knowledge, no previous research has explored health professionals' perspectives on nutrition in DFU. The combination of quantitative and qualitative research captures a broad spectrum of perspectives and latent insights into health professional perspectives on nutrition assessment and management of DFU, and their barriers and enablers to the implementation of nutrition into their care for this population. Health professionals recruited were experienced in DFU and actively working or had recently worked in the DFU space, and therefore the perspectives are likely reflective of wound health professionals in the modern context. Furthermore, our sample was heterogeneous, including health professionals from various areas and different health professional backgrounds. Thus, findings likely to be representative of health professionals working in the DFU space in Australia. Additionally, we utilised the Theoretical Domains framework, an existing framework, to develop the survey.[45]

Whilst health professionals were recruited on the national level, the majority lived in metropolitan and regional areas, and therefore the sample may not be representative of those working in rural and remote areas. Additionally, there may be dissonance between health professionals' perspectives and their actions. Moreover, we cannot distinguish between order bias with survey questions which may occur. For example, regarding malnutrition screening tools used in practice, this study found the Malnutrition Screening Tool was utilised more frequently than other tools, however this may be due to order bias.

6.2 | Conclusion

The results of the current mixed method study indicate many health professionals lack confidence in their ability

to conduct nutrition assessment and management, are uncertain their nutrition management will be effective in supporting wound healing outcomes, and are uncertain their nutrition intervention would lead to adequate dietary behaviour change by the individual with DFU. The development of a clinical pathway standardising the need for nutrition screening, assessment and intervention for those with DFU and professional development for health professionals providing care to those with DFU is imperative to improving health professional awareness and implementation of medical nutrition therapy in their practice.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A: INTERVIEW GUIDES

Aim: The primary aim of this study is to determine how health care practitioners who currently manage or have recently managed DFU perceive their role in dietary

assessment and management, and secondly, to further explore the barriers and facilitators to assessment and management of nutrition in patients with DFU.

For health professionals involved in the care of those with diabetes-related foot ulceration except dietitians and diabetes educators.

A.1. | INTERVIEW GUIDE HEALTH PROFESSIONALS

A.1.1. | Introductions

i. Explain purpose of interview (information statement)
ii. Consent form
iii. Gain consent for recording interview
iv. Mention that there is no right or wrong answer and they do not have to answer a question if they do not wish to, the interview can be stopped at any time and no identifiable information will remain on the transcription
v. Any questions before we start?

A.1.2. | Demographic data

i. Age
ii. Gender
iii. Type of health professional
iv. Confirm currently practicing and working with those with a DFU
v. Years of experience as HP
vi. Duration of experience with this population
vii. Postcode of employment
viii. Employment type—full-time, part-time or casual?
ix. Employment setting (hospital inpatient, outpatient, community, private practice)
x. Frequency of work with those with DFU (daily? Weekly?)
xi. Number of DFU patients per day/week
xii. registered with Ahpra or Dietitians Australia—those dietitians working for NSW Health don't need to be registered....

1. What started your interest in wounds? (Warm up question)
2. Do you believe diet plays a role in the wound healing process of diabetes-related foot ulceration? Please elaborate and if they say yes, what is the role diet plays?
3. If you manage their diet, what do you do? Are there things you recommend more than others? Is your management specific to diabetes-related foot ulceration?
4. Does your management of the diet of individuals with diabetes-related foot ulceration differ from those living with diabetes? Why/why not?
5. Do you utilise any guidelines when assessing and managing the diet of those with diabetes-related foot ulceration?
   a. What are these guidelines?
   b. What is your understanding of these guidelines?
   c. How do you use these in your practice?
6. Are there any particular areas you are more or less confident in performing when you assess and manage the diet of individuals living with diabetes-related foot ulceration?
7. Are there any conflicting beliefs among your health profession or among the multidisciplinary team on the dietary assessment and management of those with DFU?
8. Can you tell me about how other health professionals treating these patients within your clinic/service play a role in their nutrition-related care? Can you describe how these roles might influence the care you provide for these patients? And how do those roles influence patients?

A.1.3. | Barriers

9. What are the main barriers that you encounter that affect your ability to assess and manage the diet of those with diabetes-related foot ulceration in your practice? Time, lack of skills, lack of confidence, perceptions of patients' non-compliance?
10. How do you overcome these barriers?
11. What particular strategies have you developed to overcome these barriers?

A.1.4. | Health Professionals' needs and suggestions for improvement

12. Based on your experience, what are the current needs of health professionals to help them conduct dietary assessment and help manage the diet of those with DFU?
13. What particular approach may improve health professional's uptake of the DFU and nutrition guidelines?
14. What particular strategies do you think could be developed to ensure optimal assessment and management of diet in patients with DFU?

15. What would be your most preferred way of updating you on current evidence for dietary assessment and management of DFU?
16. If the opportunity arose for you to attend professional development in assessing and managing diet for those living with diabetic foot ulceration, would you be interested?

A.1.5. | Conclusion of interview

Thank you for participating in the interview.

17. Is there anything you would like to add before I stop the recording?

Ask participant to connect you to their professional network who might be interested in the interviews.

A.2. | INTERVIEW GUIDE DIETITIANS AND DIABETES EDUCATORS

A.2.1. | Introductions

vi. Explain purpose of interview (information statement)

vii. Consent form

viii. Gain consent for recording interview
ix. Mention that there is no right or wrong answer and they do not have to answer a question if they do not wish to, the interview can be stopped at any time and no identifiable information will remain on the transcription
x. Any questions before we start?

A.2.2. | Demographic data

xiii. Age
xiv. Gender
xv. Type of health professional
xvi. Confirm currently practicing and working with those with a DFU

xvii. Years of experience as HP

xviii. Duration of experience with this population
xix. Postcode of employment
xx. Employment type—full-time, part-time or casual?

xxi. Employment setting (hospital inpatient, outpatient, community, private practice)

xxii. Frequency of work with those with DFU (daily? Weekly?)

xxiii. Number of DFU patients per day/week

xxiv. registered with Ahpra or Dietitians Australia—those dietitians working for NSW Health don't need to be registered....

What started your interest in wounds? (Warm up question)

1. Do you believe diet plays a role in the wound healing process of diabetes-related foot ulceration? Please elaborate and if they say yes, what is the role diet plays?
2. If you manage their diet, what do you do? Are there things you recommend more than others? Is your management specific to diabetes-related foot ulceration?
3. Does your management of the diet of individuals with diabetes-related foot ulceration differ from those living with diabetes? Why/why not? Explore energy and protein requirements. Education? Do priorities change? Does education change?
4. I understand that dietetics care is individualised however could you describe what are generally your highest priorities to address in relation to diet or nutrition when you see a patient with DFU? Any particular foods/nutrient as a key focus? What education materials would you commonly recommend or provide? What do you think are the main reasons why these are priorities in your practice or education with these patients?
5. Are you aware of any guidelines relating to dietary assessment OR management of individuals with diabetes-related foot ulceration?
6. Do you utilise any guidelines when assessing and managing the diet of those with diabetes-related foot ulceration?
   a. What are these guidelines?
   b. What is your understanding of these guidelines?
   c. How do you use these in your practice?
7. Are there any particular areas you are more or less confident in performing when you assess and manage the diet of individuals living with diabetes-related foot ulceration?
8. Are there any conflicting beliefs among your health profession or among the multidisciplinary team on

the dietary assessment and management of those with DFU?

9. Can you tell me about how other health professionals treating these patients within your clinic/service play a role in their nutrition-related care? Can you describe how these roles might influence the care you provide for these patients? And how do those roles influence patients?

A.2.3. | Barriers

10. What are the main barriers that you encounter that affect your ability to utilise the DFU and nutrition guidelines in your practice? Time, lack of skills, lack of confidence, perceptions of patients' non-compliance?
11. How do you overcome these barriers?
12. What particular strategies have you developed to overcome these barriers?

A.2.4. | Dietitians and Diabetes Educators' needs and suggestions for improvement

13. Based on your experience, what are the current needs of health professionals to help them conduct dietary assessment and help manage the diet of those with DFU?
14. What particular approach may improve health professional's uptake of the DFU and nutrition guidelines?
15. What particular strategies do you think could be developed to ensure optimal assessment and management of diet in patients with DFU?
16. What would be your most preferred way of updating you on current evidence for dietary assessment and management of DFU?
17. If the opportunity arose for you to attend professional development in assessing and managing diet for those living with diabetic foot ulceration, would you be interested?

A.2.5. | Conclusion of interview

Thank you for participating in the interview. Is there anything you would like to add before I stop the recording?

Would you be interested in completing a 10–15-min survey to further explore this topic?

Ask the participant to connect you to their professional network who might be interested in the interviews.