

# BMJ Open From menu to mouth: the decay pathway of nutrient intake from planned menu to consumed and characteristics of residents in an aged care facility with greater nutrient decay rates: a cross-sectional study

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## ABSTRACT

**Objectives** To observe the cascade of nutrient loss from meals planned to those provided and subsequently consumed by older people in residential care. A secondary aim was to determine the characteristics of residents with higher nutrient loss resulting in lower intake of key nutrients.

**Design** A single-centre cross-sectional study.

**Setting** An aged residential care facility in Christchurch, New Zealand.

**Participants** All low and high level of care residents except those who are end of life, enterally fed or on short-term stay were invited to participate in the study. 54 of 60 selected residents who consumed all three main meals (breakfast, lunch and dinner) for three non-consecutive days were included in the analyses.

**Main outcome measures** Nutrient contents of planned menu; nutrient contents of meals served and consumed using modified 3-day diet records; and percentage of planned nutrients served and consumed.

**Results** Vitamins C, B12 and folate had the greatest total decay rates of 50% or more from that planned to be consumed to what was actually consumed, while unsaturated fats, beta carotene, iodine and zinc had the lowest decay rates of 25% or less. Male participants and lower care level residents consumed significantly more nutrients, compared with female participants and those receiving higher level care. Increased age, female gender, higher level of care, smaller meal size, pureed diet and lower body mass index were associated with larger decay rates and lower nutrient intakes.

**Conclusions** Not all planned and served food and beverages are consumed, contributing to potential multiple nutrient deficiencies including energy and protein in the majority of aged-care residents. As a consequence, some nutrients may need to be oversupplied if consumption is to match planned intakes.

## INTRODUCTION

A worldwide high prevalence of malnutrition, specifically protein-calorie undernutrition in older people living in aged-care or

## Strengths and limitations of this study

- One researcher had gathered, entered and analysed all data, removing interobserver variability.
- All dietary data were collected using a 3-day diet records (162 food records) where all foods served and consumed were observed and recorded by one researcher, increasing the accuracy of data being collected.
- Included as many participants as possible to provide a true picture of the data being collected.
- Only one aged residential care facility was included in the study, and the results cannot be representative of all residential care facilities in New Zealand.

nursing homes, has been well described.<sup>1–5</sup> As the population aged over 65 years increases, prevention and early treatment of undernutrition could potentially avoid serious impacts on morbidity and mortality. A recent systematic review<sup>6</sup> on malnutrition in nursing homes found that approximately half the residents (47%–62%) were at risk of malnutrition and 20%–39% were malnourished. In New Zealand, it is reported that 47% of older adults recently admitted to age-related residential care are malnourished and a further 43% are at risk of malnutrition.<sup>7</sup>

Malnutrition or poor nutritional status is associated with multiple adverse outcomes including risk of infections,<sup>8,9</sup> pressure sores,<sup>10</sup> falls,<sup>11</sup> increased length of hospital stay<sup>12</sup> and mortality<sup>12</sup> in older people. Hence, malnutrition affects quality of life and increases healthcare costs. Causes of malnutrition in older people are multifactorial. Some nutritional factors associated with undernutrition include poor appetite, low protein intake,

slow eating and dysphagia<sup>4</sup> as well as other known 'geriatric syndromes' such as depression, dementia, functional dependency and multiple comorbidities.<sup>13</sup> These studies have all looked at the end result of malnutrition. The common response is to ensure that meals in residential care are planned to obviate this problem. However, what is planned is not necessarily what is eaten.

To our knowledge, there are no studies that describe the decay rates of nutrients from the menu to food consumed by residents living in aged-care facilities. Therefore, the purpose of this paper is to assess the 'total decay rate' of selected nutrients between planned meals for an aged-care facility and those actually consumed by the resident. We also aimed to determine the characteristics of residents with higher decay rates and lower intake of key nutrients. In our study, we considered a nutrient to have the greatest decay rate if less than 50% of the planned nutrient was consumed by the residents. Alternatively, we defined nutrient with the lowest decay rate if more than 75% of the planned nutrient was consumed.

## METHODS

The protocol for this single-centre cross-sectional study is described elsewhere.<sup>14</sup> Briefly, residents receiving lower levels of care (rest home) and higher level of nursing and clinical care (hospital level) at a single aged-care facility in Christchurch, New Zealand, were invited to participate in the study. Exclusion criteria were short-term stay, end-of-life, and enterally fed residents. Informed consents were obtained from the participants, next of kin or their legal representative for the study and their clinical records were accessed to obtain weight, height, body mass index (BMI), functional levels, medical diagnoses and medications.

The 4-week cycle menus including recipes were obtained from the facility, and by analysing these menus, the average daily nutrients content was determined for 'meals planned' for the standard serving size used at the facility. The daily menu includes three main meals (breakfast, lunch and dinner), three snacks (morning tea, afternoon tea and supper) and beverages and is designed to meet the recommended daily intakes (RDIs) of most residents. Residents can choose between a 'standard serving' size, and a 'smaller serving' size, which is approximately 50% the size of the standard serving for lunch and dinner meals. The desserts were served only in standard serving size. Pureed meals (standard size only) were also provided to selected residents who required these. Information on 'meals served' and 'meals consumed' for individual participants were obtained using a combination of weighed/estimated 3-day diet records to minimise work load and interruptions during meal services. To do this, food items for small and standard serving sizes were weighed using a Salter Model 1010 electronic kitchen scale with accuracy to within  $\pm 1$  g (Salter Housewares Ltd, Kent, UK, range 1–2000 g), then each participant's meal was photographed before and after consumption to estimate

weights of food or beverage provided and consumed. The weight of the food and beverages consumed was calculated by subtracting the estimated wastage (eg, 0%, 25% and 50%) from each served item. A research dietitian collected the diet records for three non-consecutive days (two weekdays and one weekend day) for three main meals and three snacks as well as beverages provided (including oral nutritional supplements) and consumed by the participants. 'Meals consumed' also included additional food consumed by participants such as food or beverages brought in by their friends and family or consumed outside the facility as reported by the participant or the family. Where possible, packaging was checked to determine the ingredients and the weight of these extra food or beverages consumed. Similarly, any extra food or beverages consumed overnight (between supper and breakfast) were recorded the next morning from participants who could recall. All nutritional analyses were conducted using FoodWorks 8 Professional Edition (version 8.0.3553, 2015, Xyris Software, Highgate Hill, Australia). Only those participants who consumed all three main meals at the facility (rather than eating outside of the facility) were included for analyses.

Estimated energy requirement was calculated using the Schofield Equation<sup>15</sup> of  $((0.049 \times W) + 2.459) \times AF$  for men and  $((0.038 \times W) + 2.755) \times AF$  for women aged  $>60$  where  $W$  is for weight and  $AF$  is activity factor of 1.2 for bed or chair bound and 1.4 for sedentary but mobile residents. The individual estimated protein requirement was calculated using the recommended 1.07 g/kg for males and 0.94 g/kg for females.<sup>16</sup> Average nutrients served and consumed were determined by calculating the average from all individual diet records analysed. These were then compared with either estimated average requirement or adequate intake (AI) for Australia and New Zealand<sup>16</sup> as applicable for mean nutrient intake by the participants. The percentage of participants meeting the RDI was calculated using the average of 3-day diet records per participant. The average percentage of each nutrient served and consumed was obtained by averaging the individual nutrient results of food records compared with those planned on the menu on the day.

Non-parametric Mann-Whitney  $U$  tests were conducted to compare the percentage of planned nutrients consumed between two groups (ie, gender, level of care and cognitive function). Linear regression models were used to describe the relationships between the decay rates of macronutrients from planned to consumed with age and BMI. A  $p$  value of  $<0.05$  was considered statistically significant.

## Patient and public involvement

Patients/participants were not involved in the development of the research question and design and outcome measures.

## RESULTS

Data from a total of 54 residents were included in the analyses. Participant characteristics are shown in [table 1](#). The

**Table 1** Baseline demographic and features of 54 participants

Characteristics	All (n=54)	Men (n=12)	Women (n=42)
Average age±SD (years)	86.7±6.4	86.6±5.3	86.8±6.8
Age range (years)	67–99	78–94	67–99
Ethnicity			
NZ European	49 (91%)	12 (100%)	37 (88%)
Other	5 (9%)	0 (0%)	5 (12%)
Average BMI (kg/m <sup>2</sup> )	23.7	25.5	23.2
BMI <18.5	8 (15%)	0 (0%)	8 (19%)
BMI <20	12 (22%)	0 (0%)	12 (29%)
BMI 20–24.9	23 (43%)	7 (59%)	16 (38%)
BMI 25–29.9	14 (26%)	4 (33%)	10 (24%)
BMI ≥30	5 (9%)	1 (8%)	4 (9%)
Level of care			
Rest home	24 (44%)	6 (50%)	18 (43%)
Hospital	30 (56%)	6 (50%)	24 (57%)
Comorbidities			
Cardiovascular	40 (74%)	10 (83%)	30 (71%)
Central nervous	28 (52%)	7 (58%)	21 (50%)
Respiratory	15 (28%)	2 (17%)	13 (31%)
Thyroid	6 (11%)	1 (8%)	5 (12%)
Musculoskeletal	30 (56%)	6 (50%)	24 (57%)
Diabetes	9 (17%)	2 (17%)	7 (17%)
Cognitive impairment	17 (31%)	4 (33%)	13 (31%)
Psychiatric	13 (24%)	1 (8%)	12 (29%)
Cancer	14 (26%)	6 (50%)	8 (19%)
Lower GI	11 (20%)	4 (33%)	7 (17%)
Functional levels			
Able to mobilise	38 (70%)	8 (67%)	30 (71%)
Bed/chairbound	16 (30%)	4 (33%)	12 (29%)
Normal swallow	46 (85%)	10 (83%)	36 (86%)
Dysphagia requiring pureed diet	8 (15%)	2 (17%)	6 (14%)
Median number of regular medications (IQR)	8 (6.25–10)	9 (5–11)	8 (7–9.75)

BMI, body mass index; GI, gastrointestinal; NZ, New Zealand.

mean age was 86.7±6.4 years, and all except one participant were aged over 70 years. Forty-two participants (78%) were women and 56% of the participants were receiving hospital (high) level of care with 30% bed or chair bound.

Half of the 54 participants received standard size meals, and the other half received smaller meals for lunch. All male participants received standard meals, while 15 (36%) female participants received standard meals, and the remaining were on smaller meals. For macronutrients, a large discrepancy in served protein was seen (residents on smaller meals received 20% less protein on average compared with those on standard size meals, online supplementary file 1), while least difference was seen in total fats served (2%). Both participants on standard and small meals did not consume all nutrients served.

Participants on smaller meals were served and consumed a significantly lower percentage of nutrients from the planned menu compared with standard meals for most nutrients except for total fat, saturated, monounsaturated and polyunsaturated fats and cholesterol, niacin, vitamins C and E, folic acid, folate, retinol, sodium and iron.

The average nutrients (of 162 diet records) served and consumed by the 54 participants as well as number (%) of participants meeting the RDIs are summarised in table 2. The menu did not fulfil RDIs or AIs for retinol, water, fibre, magnesium, calcium, phosphorous and iodine. Additionally, the menu exceeded the recommended % fat contribution to total energy, while %protein was suboptimal. The majority of participants did not consume enough to meet the RDIs for vitamins E, B6, B12, folate, potassium, iron,

**Table 2** Recommended intakes compared with nutrients planned on the menu, meals served and consumed and number of participants (%) meeting the recommendation

	RDI/AI Men >70 years	RDI/AI Women >70 years	Meals planned	Average nutrients (% of planned nutrients) and overall number of participants (%) who would meet the recommendations according to			
				Served menu		Food consumed	
				Average, n (%)	Overall, n (%)	Average, n (%)	Overall, n (%)
Energy (kJ)	IR		8790	8060 (91)	39 (72)	6440 (73)	20 (37)
Total protein (g)	81*	57*	72.1	64.1 (89)	29 (54)	49.8 (69)	12 (22)
% protein	15–25		13.8	13.4	13 (24)	13.0	8 (15)
Total fat (g)	NA		88.5	80.8 (92)		65.5 (74)	
% fat	20–35		37.8	37.6	17 (31)	38.0	15 (28)
Saturated fat (g)	NA		40.6	35.9 (88)		29.6 (72)	
Polyunsaturated fat (g)	NA		10.3	10.5 (111)		8.29 (88)	
Monounsaturated fat (g)	NA		29.0	26.6 (94)		21.3 (75)	
Cholesterol (mg)	NA		290	26.6 (94)		21.3 (75)	
Total carbohydrates (g)	NA		244	222 (90)		177 (72)	
% carbohydrates	45–65		46.4	46.1	28 (52)	46.2	32 (59)
Sugars (g)	NA		146	125 (85)		99.0 (67)	
Water‡ (g)	3400†	2800†	2570	2230 (86)	0 (0)	1550 (60)	0 (0)
Fibre (g)	30†	25†	23.1	20.3 (86)	4 (7)	15.8 (67)	3 (6)
Total vitamin A equivalent (µg)	NA		1260	1220 (96)		920 (73)	
Retinol (µg)	900*	700*	566	496 (86)	3 (6)	404 (69)	0 (0)
Beta carotene equivalents (µg)	NA		4200	4350 (121)		3080 (88)	
Thiamin (mg)	1.20*	1.10*	2.42	1.80 (74)	37 (69)	1.43 (60)	29 (54)
Riboflavin (mg)	1.60*	1.30*	2.69	2.39 (87)	49 (91)	1.94 (71)	48 (89)
Niacin (mg)	NA		19.8	15.8 (79)		12.4 (62)	
Niacin equivalents (mg)	16*	14*	34.0	28.5 (83)	54 (100)	22.2 (65)	44 (81)
Vitamin C (mg)	45*		232	84.5 (37)	49 (91)	64.2 (28)	34 (63)
Vitamin E (mg)	10†	7†	11.3	8.08 (72)	33 (61)	6.42 (28)	19 (35)
Vitamin B6 (mg)	1.70*	1.50*	1.57	1.08 (73)	2 (4)	0.84 (57)	2 (4)
Vitamin B12 (µg)	2.40*		4.03	2.40 (63)	26 (48)	1.89 (49)	15 (28)
Folic acid (µg)	NA		259	205 (77)		158 (61)	
Folate food (µg)	NA		375	229 (62)		181 (49)	
Total dietary folate equivalent (µg)	400*		841	566 (66)	35 (65)	440 (52)	26 (48)
Sodium§ (mg)	460–920†		2400	1970 (82)	54 (100)	1550 (64)	53 (98)
Potassium (mg)	3800†	2800†	3320	2590 (76)	10 (19)	2050 (61)	3 (7)
Magnesium (mg)	420*	320*	268	257 (94)	7 (13)	201 (74)	1 (2)
Calcium (mg)	1300*		871	775 (89)	0 (0)	629 (72)	0 (0)
Phosphorus (mg)	1000*		1320	1140 (87)	39 (72)	917 (70)	22 (41)
Iron (mg)	8*		14.4	9.57 (66)	36 (67)	7.76 (54)	25 (46)
Zinc (mg)	14*	8*	8.63	8.32 (97)	21 (39)	6.43 (75)	8 (15)
Selenium (µg)	70*	60*	60.0	52.8 (91)	9 (17)	40.5 (70)	2 (4)
Iodine (µg)	150*		122	135 (108)	17 (31)	103 (82)	8 (15)

\*Recommended dietary requirement.

†AI.

‡Total water includes water from food and fluids.

§Discretionary salt added during cooking or at the table not included.

AI, adequate intake; IR, individual requirement; NA, not available; RDI, recommended daily intake.

**Table 3** Comparison of average nutrients served and consumed among men and women

	Meals planned	Meals served (% of planned)		Meals consumed (% of planned)		P value*
		Male (n=12)	Female (n=42)	Male (n=12)	Female (n=42)	
Energy (kJ)	8790	9010 (103)	7780 (88)	8000 (89)	6000 (68)	<0.001
Energy (kcal)	2100	2150 (103)	1860 (88)	1910 (89)	1430 (68)	<0.001
Total protein (g)	72.1	71.3 (96)	62.0 (86)	63.3 (86)	45.9 (65)	<0.001
% protein	13.8	13.5	13.4	13.5	12.8	0.06
Total fat (g)	88.5	91.3 (102)	77.8 (89)	81.7 (92)	60.9 (70)	<0.001
% fat	37.8	37.5	37.5	37.6	37.9	0.74
Total carbohydrates (g)	244	245 (99)	216 (88)	216 (87)	166 (68)	<0.001
% carbohydrates	46.4	44.6	46.3	44.2	46.4	0.29
Water (g)	2570	2590 (100)	2120 (82)	1990 (77)	1430 (55)	<0.001
Fibre (g)	23.1	22.2 (93)	19.8 (85)	19.4 (81)	14.7 (65)	<0.001

\*Mann-Whitney U test for % nutrients consumed between male and female participants.

zinc and selenium in addition to those nutrients noted above.

An average of 8790 kJ and 72.1 g of protein per day were planned on the menu; however, on average 91% of energy and 89% of protein were served and just 73% and 69% of planned energy and protein, respectively, were consumed. The proportions of total fat (74%) and carbohydrate (72%) intake were similar to total energy consumed at 73%. More than half (61%) of the participants did not meet their estimated energy requirement, and 39 participants (72%) did not meet their estimated protein needs.

Nutrients with the greatest decay rates (<50% planned nutrients consumed) were: vitamin C (28%), followed by vitamin B12 (49%) and folate (49%). The greatest decay occurred between the amount of nutrients planned and served. The nutrients that were consumed the most with lowest decay rates (>75% planned nutrients consumed) were: polyunsaturated fats (88%), beta carotenes (88%) and iodine (82%).

Sixteen (30%) of the participants were receiving oral nutritional supplements that provided on average 1330 kJ (16% towards total intake per day) and 12.3 g protein (17%) served and 1140 kJ (21%) and 9.77 g protein (21%) consumed among these participants on supplements.

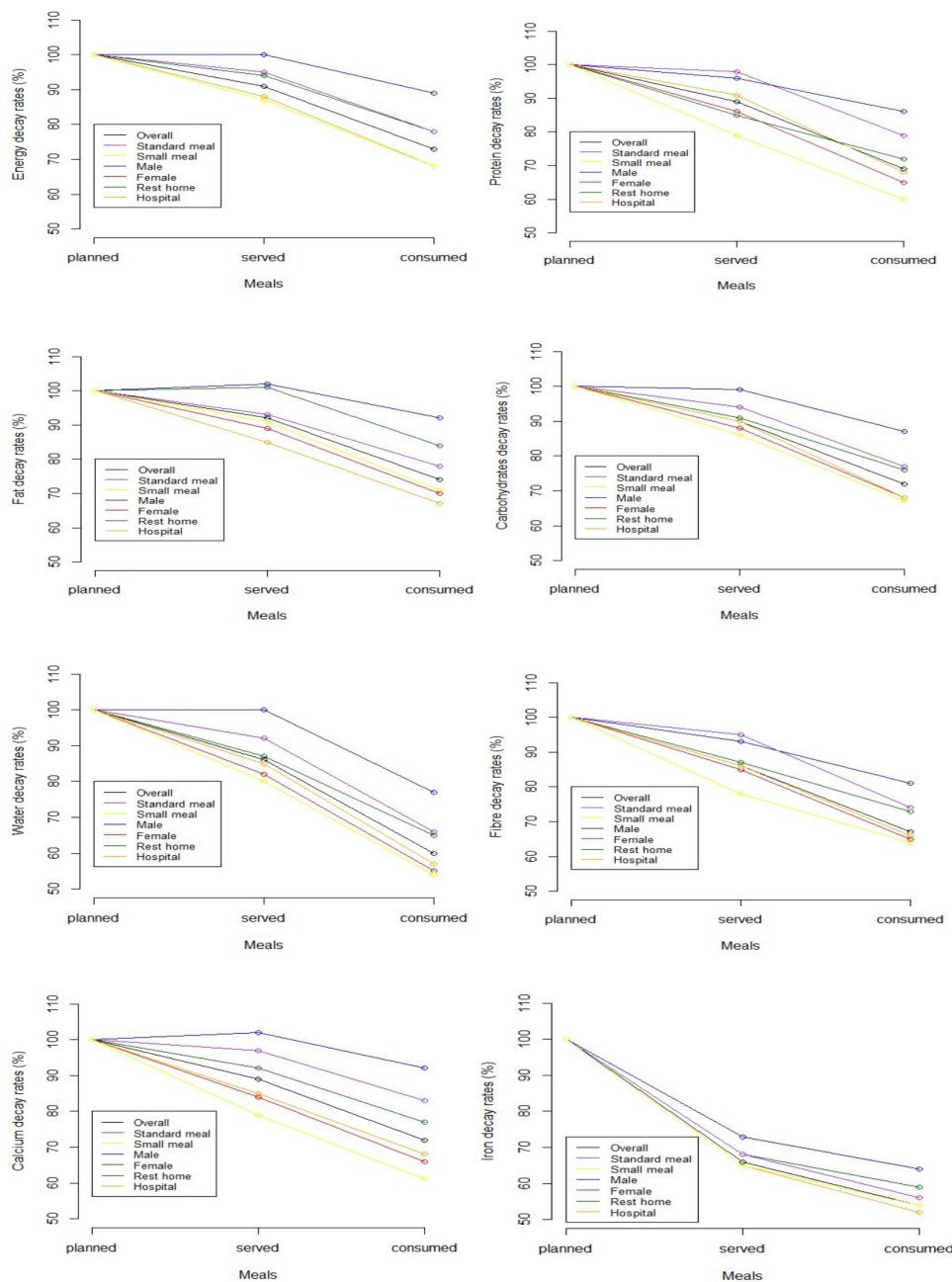
Table 3 summarises the differences between men and women for nutrients served and consumed. As mentioned previously, all male participants were served the standard meal serving size, and therefore, the served macronutrients were close to 100% of that planned, and these participants consumed approximately 90% of the planned macronutrients. Women where the majority (64%) had selected smaller meals at mid-day were served just below 90% of planned macronutrients on average and consumed approximately 70% of planned. Hence, there were significant differences ( $p < 0.001$ ) between men and women for the decay rates for consumed macronutrients except for %protein, %fat and %carbohydrates contribution to total energy.

**Table 4** Comparison of average nutrients served and consumed among rest home and hospital level of care participants

	Meals planned	Meals served (% of planned)		Meals consumed (% of planned)		P value*
		Rest home (n=24)	Hospital (n=30)	Rest home (n=24)	Hospital (n=30)	
Energy (kJ)	8790	8300 (94)	7860 (88)	6950 (78)	6040 (68)	<0.001
Energy (kcal)	2100	1980 (94)	1880 (88)	1660 (78)	1440 (68)	<0.001
Total protein (g)	72.1	61.6 (85)	66.0 (91)	51.1 (72)	48.7 (68)	0.170
% protein	13.8	12.5	14.2	12.2	13.6	0.009
Total fat (g)	88.5	87.1 (101)	75.8 (85)	72.6 (84)	59.9 (67)	<0.001
% fat	37.8	39.5	36.2	39.8	36.5	0.003
Total carbohydrates (g)	244	225 (91)	220 (90)	189 (76)	167 (68)	0.006
% carbohydrates	46.4	45.2	46.9	45.0	47.1	0.06
Water (g)	2570	2260 (87)	2200 (85)	1680 (65)	1450 (57)	0.007
Fibre (g)	23.1	21.0 (87)	19.8 (86)	17.5 (73)	14.4 (66)	0.006

\*Mann-Whitney U test for % nutrients consumed between rest home and hospital level of care participants.





**Figure 1** Decay rates of average energy, macronutrients, calcium and iron from planned menu by meal sizes, gender and levels of care.

Table 4 summarises the nutrients served and consumed by rest home and hospital level participants. Hospital level participants had significantly greater decay rates for all nutrients listed ( $p < 0.05$ ) except for protein and sugar compared with rest home participants. However, hospital participants were served more protein and sugar compared with rest home participants.

Figure 1 depicts the decay rates of average energy, macronutrients, calcium and iron planned, served and consumed by meal size, gender and levels of care. In general, male participants had the smallest decay rates, while small meal size, female and hospital-level participants had the greatest decay rates resulting in lower intakes of energy and

nutrients. Female and hospital participants had the same decay patterns for energy and iron.

Seven (41%) of the participants with cognitive impairment were either assisted or fully fed by the staff. The decay rates were similar, and there were no statistically significant differences between those with or without cognitive impairment (online supplementary file 2). Similarly, there were no significant differences between the decay rates of macronutrients between mobile and bed or chair-bound participants (online supplementary file 3). In contrast, six participants who received pureed meals consumed significantly lower total energy, fat, carbohydrates and water with

greater decay rates compared with participants on regular textured diet (online supplementary file 4).

Linear regression models showed significant negative associations between decay rates (from planned to consumed nutrients) and age for macronutrients. Specifically, the reductions were 11.5% ( $p=0.004$ ) for energy, 12.5% ( $p=0.005$ ) for protein, 9.7% ( $p=0.055$ ) for fat and 11.7% ( $p=0.003$ ) for carbohydrates for every 10-year increase in age. Similarly, there were significant negative associations between decay rates and BMI. These reductions were 16.5% ( $p=0.002$ ) for energy, 14.3% ( $p=0.020$ ) for protein, 17.5% ( $p=0.010$ ) for fat and 14.7% ( $p=0.007$ ) for carbohydrates for every  $10\text{ kg/m}^2$  decline in BMI.

## DISCUSSION

To our knowledge, this is the first study to investigate the cascade effect of nutrient intake decay from a planned menu to what is actually consumed by residents living in an aged-care facility. Our primary aim was to observe the total decay rate (percentage of planned nutrients consumed by the residents) to help identify those who are most at risk of inadequate nutrient intake. The results showed that not all food and beverages served were consumed by the residents. Those consuming smaller size meals, female and hospital (high) level of care participants had the greatest decay rates for total energy, macronutrients, iron and calcium. We acknowledge that in our study, only female residents (64% of female residents) had selected small meal size, and the decay rates for meals served and consumed are affected for women for this reason. Among macronutrients, least decay rates were seen in fats followed by carbohydrates and protein had the greatest decay rates. While protein intake is known to be important in older adults, particularly to prevent or reduce the effects of sarcopenia, our study indicated that the majority (72%) of aged-care residents did not consume adequate protein. Similarly 61% of these residents did not meet their estimated energy requirements. Furthermore, increasing age and reduction in BMI were also associated with significantly lower energy and macronutrient intake.

We found that vitamin C had the greatest decay rates; however, 91% of the participants were served and 63% consumed the recommended 45 mg/day on average. The discrepancy was due to the fact that vitamin C-rich items such as orange juice, cranberry juice and kiwifruit on the menu were not necessarily selected by the participants. Additionally, not all participants consumed all of the canned or fresh fruit being served, hence the drop in percentage of residents meeting the recommended intake. Other common food wastes that contributed to decay rates of macronutrients included bread or toast, particularly the crusts, preordered sandwiches at the evening meal, coleslaw, green salads, milk served with breakfast cereals, porridge and in tea, meats, pasta dishes, instant puddings offered as pureed desserts, some vegetables such as courgettes, leeks and cabbage. The greater decay rates of protein may be due to items such as meats and milk-containing food and beverages

being left unconsumed. However, it was evident that the %protein contribution to total energy was below recommendation and % fat exceeded the recommended level on the menu, and those participants on smaller meals were served significantly less protein (meats) but similar amounts of fats to those on standard serving size.

We did not observe any significant differences in nutritional intake or decay rates between those with cognitive impairment and those without. All food intakes from breakfast to supper were observed; however, the details of food consumed overnight were collected from those who could recall. We believe that this would not have made a significant impact on the results as the menu (which covers all food offered from breakfast to supper) is intended to meet most residents' nutritional requirements. The reason for not observing significant differences may be due to feeding assistance provided by staff to 41% of the participants with cognitive impairment. Indeed, the provision of regular feeding or eating assistance has been shown to improve food intake in aged-care residents.<sup>17</sup> However, feeding assistance is often not provided in care facilities due to staff and time constraints. Provision of such assistance is also important since malnourished patients are more likely to consume  $\leq 50\%$  meals compared with well-nourished patients.<sup>18</sup>

Our study found that, on average, residents consumed 6440 kJ (1540 kcal/day), which is similar to that described in previously published studies<sup>17 19–22</sup> (average 1507–1522 kcal/day). However, the average protein intake of 49.8 g/day was much lower than that described previously<sup>17 20–22</sup> (54.8–58 g/day). Similar to our study, Buckinx *et al.*<sup>21</sup> also found that not all meals served in nursing homes were consumed by the residents and that there were significant differences between energy and macronutrient contents of foods served and consumed. Equally, a Canadian study<sup>19</sup> found that despite an average normal BMI, these elderly residents did not meet the requirements for macronutrient and micronutrient intake. These studies support our findings that the majority of aged-care residents are at risk of nutritional inadequacy.

It is important to note that although we found that male participants had the lowest decay rates for nutrients, the majority of study participants including men were found to have inadequate consumption of multiple nutrients namely protein, water, fibre, vitamins A, E, B6, B12, folate, potassium, magnesium, calcium, phosphorus, iron, zinc, selenium and iodine. Unfortunately, the RDI of 11 (69%) of these 16 nutrients was not met by the planned menu, particularly for men who have higher RDIs.

We should emphasise that a residential care institution should deliberately plan to oversupply meals to its residents, rather than not serving enough. This means that what is served should, on average, always be greater than what is consumed. However, this is the first study to quantify these gaps and to show which nutrients may be at greater risk of being underconsumed. However, serving meals that are too large can discourage people from eating. A solution may be to offer second servings at meal



times and to offer snacks between meals. In both cases, ideally, these would be oversupplied with nutrients known to be at risk, such as protein, fibre, vitamins A, B6, magnesium, calcium and zinc. Furthermore, given protein had one of the greater decay rates, the menu should focus on offering more protein at each meal rather than fats as fats are generally well consumed by the residents.

As with any study, there are potential limitations to this research. As all recruitment occurred at one facility, and all participants were Caucasian, the study participants may not be representative of all New Zealand aged-care facilities. One research dietitian collected all dietary data eliminating interobserver error and used weighed food record in combination with a validated visual assessment method of plate waste.<sup>23</sup> Our study did not screen for malnutrition; however, 22% of the participants were found to have low BMI (<20 kg/m<sup>2</sup> including 15% with BMI <18.5). We suggest future studies compare differences in nutrient intake between well-nourished and malnourished residents identified using a nutritional screening tool such as Mini Nutritional Assessment.<sup>24</sup> Some important nutrients such as vitamin D were not analysed in this study; however, they could be assessed in future studies.

## CONCLUSION

Despite menu planning, approximately 90% of nutrients planned on the menu are served to the residents and about 70% are consumed. Subsequently, multiple nutrient deficiencies exist including suboptimal energy and protein intake in aged-care residents in New Zealand. Female sex, increasing age, smaller meal size, hospital level of care, lower BMI and consuming a pureed diet were associated with lower nutrient intake with greater nutrient decay rates. However, male residents were more likely to consume most of nutrients planned and served at the facility. The study highlighted the need to increase protein and energy content on the menu, and we suggest routinely offering protein-rich snacks as in-between meal snacks and offering larger meals or alternatively second helping to residents.

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