Low nutrient intake and frailty among overweight and obese migrant women from ethnically diverse backgrounds aged 60+ years: a mixed-methods study

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'Low Nutrient Intake And Frailty Among Overweight And Obese Migrant Women From Ethnically Diverse Backgrounds Aged 60+ Years: A Mixed-Methods Study'

INTRODUCTION

Frailty has become the focus of extensive research due to the ever-increasing aging of the global population. Frailty is characterized as a disorder of multiple physiological systems in which homeostatic mechanisms start failing, increasing the risk of declines in cognitive and physical function.[1-3] Furthermore, longitudinal studies have demonstrated a greater prevalence of cardiovascular disease and diabetes among frail older people,[4] and a greater frailty burden for women in comparison to men.[5,6] Therefore, identifying and treating individuals at risk of frailty may help delay its negative consequences and reduce the financial, social, and personal burdens these consequences place upon individuals, families and societies.[7,8]

One of the most widely used definitions of frailty is the frailty phenotype proposed and validated by Fried and colleagues.[2] This battery of tests identifies people as frail when they meet three or more of five criteria: relatively weak grip strength, unintentional weight loss, self-reported exhaustion, slow walking speed and low levels of physical activity (PA). The inclusion of unintentional weight loss is used as a proxy measure of dietary inadequacy, which is congruent with the conceptualization of frailty as a wasting disorder.[2-3] However, obesity can also be linked with frailty, as

indicated by the greater risk of physical function decline and pro-inflammatory state commonly found among older adults who are obese.[9]

In older adults, the use of unintentional weight loss in the definition of frailty is problematic as this measure may not be sensitive enough to reflect reduced energy and nutrient intakes.[8] Weight loss will not occur if energy intake matches energy expenditure, however a diet that is adequate in energy can still be deficient in certain nutrients, increasing a person's risk for frailty. Therefore, we hypothesize that a low intake of energy and selected nutrients is a stronger predictor of frailty in overweight/obese older women from diverse ethnic backgrounds than unintentional weight loss. There is limited evidence examining the association between frailty as a syndrome and nutrient intakes, and this has been conducted in predominantly White older adults.[8] Thus, very little is known about these associations in older adults from diverse ethnic backgrounds. In addition, to develop interventions that can effectively delay or prevent frailty in older women from diverse ethnic backgrounds, more information is needed to explore if there are links between perceptions of body weight, dietary intake and physical function in a population with disproportionately higher rates of overweight and obesity.

Therefore, the aims of this study were to: 1) examine the associations between dietary/nutrient intake and frailty in a sample of older women (≥60 years) from diverse ethnic backgrounds living in the UK; 2) to gain a greater understanding of the potential links between women's perceptions of body weight, dietary intake and physical function.

METHODS

Study Design

A cross-sectional, mixed-methods design was employed, using 24-hr dietary recall interviews that were enhanced with the addition of a qualitative semi-structured interview. These methods allowed for the quantitative estimate of energy/nutrient intake and its association with frailty, as well as providing insights into women's perceptions of their body weight, dietary intake and physical function.

Recruitment and Participants

A convenience sample of first generation migrant women from Ireland, Jamaica, Montserrat, St Kitts and Nevis, India, Pakistan, Bangladesh, Yemen, Sierra Leone, Somalia, and Eritrea were recruited to participate in the study. Inclusion criteria included being at least 60 years of age, with no medical conditions affecting memory (e.g., dementia), and the ability to walk 15ft with no or minimal assistance (i.e., use of a walking stick). Community-dwelling women living on their own or with family members were recruited using maximum variation sampling[10] to achieve our goal of recruiting a sample across the ranges of age, migration backgrounds, socio-economic status, and main ethnic groups living in the geographic region. This was achieved by using the most recent Birmingham census data to identify the most representative migrant groups.[11] Community centres serving specific migrant and older adult groups

were contacted and informed about the study. Those in leadership roles at these centers facilitated access to potential participants so they could be approached and informed of the purpose of the study. Participants were recruited via word-of-mouth and snowballing.[12] Ethics approval was granted by The University of Birmingham Ethics Committee (reference No. ERN_13-0557). All participants provided written informed consent.

Data Collection

Data were collected at the participants' time and location of choice (e.g., homes or community centers). For participants not fluent in English, trained interpreters fluent in Punjabi, Bengali, Arabic and Somali provided simultaneous translation during recruitment and data collection. Socio-demographic information was gathered via a researcher-administrated questionnaire.

Dietary Intake.

A multiple-pass 24-hr dietary recall interview was conducted to gather data on the types and amounts of foods consumed on the previous day via a standard protocol.[13] Information was also obtained on nutrient supplement use. A photographic food atlas assisted with the estimation of portion sizes.[14] The first author (DCG), a dietitian, trained in dietary assessment conducted all 24-hr dietary recalls. Data coding and processing was conducted by DCG, with oversight from JLT who has extensive expertise in dietary assessment. These procedures enabled a standardized data entry and analysis process. The dietary recall interview was audio-recorded to ensure accuracy of quantitative data entry and to facilitate the collection of additional

qualitative information. When participants stated that the previous day did not reflect their habitual diet (e.g., they had engaged in fasting practices), the 24-hr dietary recall was repeated later in the same week on a day that was identified by participants as being representative of their habitual intake. This occurred in 5 participants. Data were not gathered during periods of major religious observances (e.g., Ramadan, Diwali). All recalls were conducted during weekdays, excluding Monday. Nutrient analysis was completed using DietPlan 6.0 software (Forestfield software Ltd 2006, Horsham, UK), which included standard and supplemental food composition databases that covered the range and ethnic diversity of foods consumed in the UK.

Similarly to methods reported by Bartali and colleagues,[8] low intake was defined as the lowest quintile of the distribution of energy (<13 kcal/kg) and specific nutrients: protein <30 g, vitamin D <0.5 μg, vitamin E <2.5 mg, retinol <101 μg, vitamin C <32 mg, folate <127 μg, iron <5.6 mg, calcium <349 mg, and zinc <3.6 mg. A nutritional score was obtained by summing the number of nutrients categorized as low intake. This nutritional score was subsequently categorized into a low intake of 0, 1-3, or >3 nutrients. A low intake of >3 nutrients was classified as poor nutritional status.

Anthropometric measures and assessment of frailty.

Anthropometric measures included height measured to the nearest mm (SECA 213 portable stadiometer), weight to the nearest 0.1 kg (SECA 899 digital scale), and hip and waist circumference (WC) measured to the nearest cm using an extractable tape measure. All anthropometric measurements were taken with the participant wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight divided

124 by height squared (kg/m^2), and waist-to hip-ratio (WHR) as waist circumference
125 divided by hip circumference (cm).
126 Frailty status was assessed using a modified version of the original frailty definition
127 developed by Fried and colleagues.[2] This included: 1) Exhaustion, defined using self-
128 reported fatigue from two questions from the Center for Epidemiological Studies-
129 Depression (CES-D) depression scale ("I felt that everything I did was an effort," and
130 "I could not get going.") Participants who reported having these feelings for ≥3 days
131 over the previous week to either or both questions received positive scores for
132 exhaustion; 2) Slow walking speed, with the highest quintile of the time needed to
133 walk a distance of 15 feet, adjusted by height (>14.5 seconds for height ≤ 157.7 cm
134 and >9.7 seconds for height > 157.7 cm); 3) Weak grip strength was defined as the
135 lowest quintile for adjusted grip strength using a JAMAR hand-held dynamometer
136 (Sammons Preston Rolyan, Bolingbrook, Illinois, USA), adjusted by BMI.
137 Participants met the criteria for weak grip strength if their BMI and grip strength were
138 ≤25.8 kg/m^2 and ≤ 12 kg; >25.9- 29.6 kg/m^2 and ≤ 11 kg; >29.7- 31.6 kg/m^2 and ≤12
139 kg; and ≥31.7 kg/m^2 and ≤14 kg. A low level of PA was defined as the lowest quintile
140 of caloric expenditure (< 60 kcal/week) using the International Physical Activity
141 Questionnaire short-form modified for the elderly (IPAQ-E).[15] This version of the
142 IPAQ provides examples of activities that are more common among older adults and
143 has shown a moderate correlation ($r=0.347$, $p<0.01$), and moderate agreement $\varkappa$
144 (95%CI)= 0.448 (0.18-0.72, $p < 0.001$) with accelerometry.[16]
145
146 Since the purpose of this study was to examine the association between dietary intake
147 and frailty, similar to Bartali's study, unintentional weight loss (>10 pounds in the last
148 year) was excluded from the original frailty definition.[8] Therefore, participants with

149 >2 positive criteria were categorized as frail, while those with ≤1 positive criteria
150 were categorized as not frail.
151

152 ***Semi-structured interviews.***
153 A purposive sub-sample (n=46) across the range of age, ethnic groups and socio-
154 economic status was invited to participate in an interview that was guided by a list of
155 topics related to migration histories, dietary intake and eating behaviors, and
156 engagement in PA (migration histories and PA data not reported here). For the
157 purpose of this study, dietary topics centered on participants' perceptions of their diets
158 in relation to their body weight and frailty status (referred to as physical function
159 during the interviews). The interview guide was pilot-tested prior to the study and was
160 further revised via an iterative process throughout the data collection period. All
161 interviews were audio-taped and transcribed verbatim, with the interviews conducted
162 with participants who were not fluent in English being translated from their native
163 language into English by a trained interpreter during the interview process (n=16).
164

165 **Data Analysis**
166

167 ***Quantitative data analysis.***
168 Descriptive characteristics (means, SDs, and percentages) were calculated for socio-
169 demographic variables. To identify potential confounding factors, independent t-tests
170 or Mann-Whitney U tests (for non-parametric data) were conducted to examine any
171 significant differences in continuous variables between those classified as frail or not
172 frail, with Chi-squared or Fisher's exact tests conducted for categorical variables.

Point-biserial correlations (r_{pb}) were used to determine the association between frailty status (dichotomous variable), weight loss, and indices of overweight/obesity (e.g., BMI, WC and WHR). Multiple logistic regressions were used to evaluate the association between frailty status and each of its components with low energy intake and poor nutritional status. Separate models were conducted to test the association between nutrient intakes with frailty adjusting for confounding factors and energy intake. All statistical analyses were performed using SPSS version 21.0 (SPSS INC., Chicago, IL); alpha was set at $p<0.05$.

Qualitative data analysis.

An inductive thematic analysis of the interview transcripts was conducted, allowing for the identification of themes being driven by participants' perspectives of their diets in the context of their body weight and physical function/frailty status rather than fitting the data into a pre-existing theoretical framework.[17] Initially, a subset of transcripts were read several times by the first author and two independent researchers to identify predominant topics across the data. An initial coding frame using qualitative analysis software (QSR NVivo, version 10) was developed which formed the basis of broad coding and analysis. All of the transcripts were then coded by the first author. The coding frame was discussed and refined by all authors until consensus was reached. Data saturation was considered to have been achieved when no new or relevant information emerged from each of the various ethnic groups included in the study.[18]

RESULTS

Table 1 includes the demographic characteristics of participants. On average, participants (mean age= 70.5 ± 7.6 years) reported having 2.3 ± 1.5 diseases previously diagnosed by a doctor, with hypertension, arthritis and type 2 diabetes the most common. Over 88% of the sample was classified as overweight or obese. BMI cut-points for overweight and obesity among the Arab, Indian, Pakistani and Bangladeshi participants were those recommended by the World Health Organization for Asian populations.[19] Although participants came from all socioeconomic levels, 79% were categorized as being in the two most socio-economically deprived quintiles based on the English indices of deprivation.[20] Seventeen participants (22.4%) were classified as frail, while 23 (30.3%) and 36 (47.4%) were classified as pre-frail and non-frail, respectively. Frail participants were older and had a higher number of diagnosed diseases; these were the only demographic variables that were statistically different between frail and non-frail participants.

Frailty and low nutrient intake

Among frail participants, 82.3% had a low nutrient intake of at least one selected nutrient (Table 2). The percentage of women with frailty increased with the greater number of nutrients classified as low intake. Logistic regression analyses indicated that low energy intake was independently associated with frailty (odds ratio [OR]: 11.71, 95% confidence interval [CI]: 2.36-57.97). After adjusting for energy, age and number of diseases, poor nutritional status (>3 low nutrient intakes) was significantly associated with frailty (OR: 6.58, 95% CI: 1.01-43.08) in comparison to those women

221 who did not have a low intake of any nutrients. After adjusting for energy and other
222 confounding variables, only slow walking speed was significantly associated with
223 poor nutritional status (OR: 1.86, 95% CI: 1.31-3.07).
224
225 In addition, a low intake of retinol (OR: 10.33, 95% CI: 1.55- 68.94) and zinc (OR:
226 8.47, 95% CI: 1.04-68.80) were significantly associated with frailty after adjustment
227 for energy intake and other confounding variables (Table 3). Self-reported weight loss
228 (p=0.3 for Fisher's exact test), BMI (r_{bp}= 0.09, p=0.4), waist circumference (r_{bp}= 0.2,
229 p=0.1), and WHR (r_{bp}= 0.03, p=0.8) were not associated with frailty.
230
231 **Qualitative Interview Results**
232
233 Two main themes which linked women's perceptions of body weight, dietary intake
234 and physical function were identified. They were: 1) concerns about weight and body
235 image; and 2) perceptions about negative effects of unhealthy foods on physical
236 function and health. Specific quotes from participants have been used to demonstrate
237 the themes outlined above.
238
239 ***Weight and body image concerns.***
240 Weight and body image emerged as two issues that were particularly important to
241 participants. Data suggest that these women have become more aware of their weight
242 as they have aged. Furthermore, some participants emphasized that their weight status
243 worried them more than getting older or other health problems as the excerpts below
244 indicate:
245

246 *'I am very careful that I don't eat too much, though I am very hungry but I will leave*
247 *[the food uneaten]… I never say I want to eat more, no! ... I do not want to put on*
248 *weight, that is in the back of my mind, I never think of the heart [problem], I think of*
249 *my weight'* (Indian, 73y).
250
251 *'It doesn't bother me [the age], but when somebody says you are fat, then it hurts me!'*
252 *(Indian, 62y).*
253
254 Participants' narratives also highlighted a difficult relationship between their diets and
255 body weight, leading to feelings of frustration and shame:
256
257 *'My thinking was always eating healthy, but…I don't know how I put on so much*
258 *weight so quickly and I've been trying [to lose weight] for many years now, it's not*
259 *going down. I don't know what happened… I have gained so much I can't even get rid*
260 *of it… since I've put on weight and I am out of size as well, I think 'Oh God people,*
261 *don't see me!' …That stops me from going out, dressing up as well, meeting people or*
262 *going into places' (Pakistani, 62y)*
263
264 Given pervasive concerns about weight gain, many participants described modifying
265 their diets in an effort to lose weight. However, adopting more restrictive diets have
266 led some women to link these changes with a negative impact on their strength:
267
268 *'When you are getting older is hard to lose weight …well, I used to cut down my food*
269 *and then I think I was falling apart, I was getting weak… so I just said, "I'll just*
270 *continue [as normal]"' (African-Caribbean, 79y)*

Other participants who have also tried to reduce their food intake mentioned that they occasionally complement their '*light diets'* with certain food items in order to meet their perceived dietary requirements:

'When I feel I haven't had enough protein… and need to rebuild some of the cells, dying cells, …then I would consciously have fish or chicken and try to eat a large portion to try to convince myself that I'm eating enough protein…but no, I do a lot of light days [of decreased consumption of fat and animal products]' (African-Caribbean, 68y).

Perceptions about negative effects of unhealthy foods on physical function and health.

Participants' perceptions about the link between diet, physical function and general health were mainly driven by their beliefs about the negative effects unhealthy foods have on their mobility. For instance, some participants mentioned that eating '*fattening food'* decreases their ability to be more active:

'If I had fried food and I walk, I feel breathless yeah, so I keep in line what I am eating' (Indian, 71y)

'Like…when you eat chips [French fries] you feel so heavy and you don't feel like moving, you don't feel like running you know' (Indian, 74y)

Overall, women felt that the quality of the food they eat is associated with their general health, and that a healthy diet is an important component of healthy aging:

296 *'Health is related to what you put in your body, you are what you eat and if you put*
297 *healthy food in your body, you can expect to be healthy at this age' (African-*
298 *Caribbean, 69y)*
299

300 **DISCUSSION**
301
302

303 The present study examined the association between dietary intake and frailty in a
304 group of free-living first generation migrant older women using a mixed-methods
305 approach. Findings from this study indicated that having a low energy intake was
306 associated with frailty, and a poor nutritional status was significantly associated with
307 frailty after adjusting for energy and other confounding factors. Poor nutritional status
308 was also associated with slow walking speed, one of the criteria of the frailty
309 syndrome. The findings also provided rich insight into participants' perceptions about
310 the links between their body weight, dietary intake, and physical function.

311 Our findings support existing evidence associating frailty and its components to
312 nutrition at the nutrient level.[8] Poor nutritional status and low serum levels of several
313 nutrient biomarkers (serum carotenoids, α-tocopherol, 25-hydroxyvitamin D, and
314 vitamin B6) have been found to be related to an increased risk of frailty among
315 predominantly White older adults.[21-23] These data, in addition to the findings from the
316 present study, suggest that an inadequate diet plays a crucial role in the physical
317 function of older adults. This is of particular importance due to the body composition
318 changes associated with old age leading to loss of muscle mass (sarcopenia) that can
319 contribute to morbidity and decreased quality of life.[3]

320 There are multiple pathways in which micronutrient deficiencies can increase the risk
321 of frailty in older adults by promoting conditions commonly associated with older age
322 such as oxidative stress, impaired immunity, muscle and bone metabolism, and
323 inflammation.[24] In our study, only retinol and zinc were independently associated with
324 frailty, suggesting that these two nutrients may be of particular concern in this sample.
325 Retinol is suggested to protect cell membranes from oxidative damage related to
326 aging,[25] while both retinol and zinc play an important role in maintaining the integrity
327 of the immune system.[26] Although malnourishment is typically associated with
328 underweight, this study confirms that overweight/obese individuals can also be
329 malnourished due to consuming a poor quality diet.[27] Thus, an individual can be frail
330 and not necessarily experience weight loss.

331 Among this sample, body weight concerns emerged as a key factor influencing energy
332 and nutrient intake. Therefore, the majority of participants were more conscious about
333 eating in moderation in order to lose weight, and did not identify being concerned
334 with how their dietary intake would affect nutrient adequacy. Although it is well
335 known that body dissatisfaction is highly associated with dietary intake in younger
336 adults, it is only recently that this has been reported in older adults, especially in
337 women.[28] Among women from minority ethnic groups, body weight perceptions have
338 been reported to be more positive and accepting of larger figures and a body weight
339 consistent with medically defined overweight or obesity.[29] However, our findings
340 indicate that the women in this ethnically diverse sample are concerned about their
341 body weight and the negative consequences associated with overweight/obesity.
342 These concerns may potentially lead them to adopt restrictive eating practices that
343 may cause more harm than good. Although body dissatisfaction has been previously
344 reported in younger migrant women,[30] to our knowledge, this is the first time that this

345 has been found in a sample of older migrant women with high rates of
346 overweight/obesity.

347 Regarding the negative effects of unhealthy foods on physical function and health, a
348 few studies have found that an unhealthy diet (i.e., poor consumption of fruits and
349 vegetables, low adherence to a Mediterranean-type diet) is associated with mobility
350 limitations and disability in older adults, particularly in women.[31-33] Although this
351 association has been found to be stronger in non-obese individuals,[32] in our study
352 women felt that unhealthy foods, particularly fatty foods, were negatively related to
353 their mobility. Thus, in overweight/obese older women, healthier diets may be
354 perceived as a means of ameliorating mobility loss and further physical decline.

355 Given pervasive concerns about weight gain, findings from this study suggest that
356 older women from ethnically diverse backgrounds with a high prevalence of
357 overweight/obesity need dietary advice that promotes both the maintenance of a
358 healthy body weight and nutrient adequacy. Particularly, because both excess weight
359 and nutritionally inadequate diets are important determinants of morbidity and
360 premature mortality.[34]

361 The major strength of the present study is the inclusion of a population commonly
362 under-represented in research,[35] and little is known about dietary intake, eating
363 behaviors, and frailty in older migrant women. The mixed-methods methodology is
364 also a strength, as it allowed for the examination of dietary intake and its association
365 with frailty as well as providing important insights into women's perceptions of their
366 dietary intake and its link with body weight and physical function. In addition, the
367 interview sample size was relatively large for a mixed-methods study, and data
368 saturation was reached in all participants across the range of age and ethnic groups.

Finally, some limitations of the study need to be considered. Due to the cross-sectional study design and a relatively small sample size for the quantitative data, causal inferences cannot be made and findings may not be generalizable to the wider population of first generation older migrant women living in the UK. In addition, almost 90% of the sample was overweight or obese. Although this could be considered a strength as the sample reflects the higher prevalence of overweight/obesity in ethnic groups in the UK,[36] the findings do not include data from participants who were underweight. This could have limited the potential of finding an association between frailty, protein and other micronutrients consistently found in previous studies.[8, 23,37] In addition, BMI was used as a measure of weight status. This is problematic as BMI does not distinguish between lean tissue and fat mass, and cannot take into account the height loss that occurs with older age.[34] Studies including a larger sample of older women from ethnically diverse backgrounds using an accurate measure of body composition and nutritional biomarkers are needed to confirm our findings. A larger sample will also allow for the examination of significant differences between ethnic groups.

Another important limitation was the use of a single 24-hr dietary recall, a limitation shared with other studies conducted with older adults and 'hard to reach' populations.[38] This method was considered the most appropriate as it minimized participant burden and allowed participants with limited English literacy to fully participate in both the quantitative and qualitative aspects of the study. Limitations in willingness of participants to participate in a second 24-hr dietary recall interview, in addition to budgetary constraints, prevented the use of repeated 24-hr dietary recalls. In the present study, energy intake was relatively low and as such, under-reporting cannot be ruled out. Under-reporting has been found to be associated with female

394 gender, higher age, lower socio-economic status, and overweight/obesity.[39] Because
395 of the day-to-day variability in dietary intake, the single 24-dietary recall provided
396 data for the sample rather than an estimate of an individual's dietary intake. The
397 interviews were conducted by a trained nutritionist, and when necessary with the aid
398 of interpreters with the same ethno-cultural background who were familiar with the
399 participants' dietary habits. In addition, we enhanced the 24-hr dietary recall with an
400 in-depth probing interview that allowed for a rich exploration of habitual dietary
401 behaviors not possible with a standard 24-hr dietary recall. Low dietary and nutrient
402 intakes in older adults are not uncommon given important changes in body
403 composition, intestinal absorption and decreased levels of PA.[40] In our study, women
404 were highly sedentary, which could have also influenced their energy intake.
405 Nevertheless, misreporting may have occurred and as such, our results should be
406 interpreted in light of this limitation.

407

408 **IMPLICATIONS FOR RESEARCH AND PRACTICE**
409

410

411 Findings from this study indicate that among a group of mainly overweight/obese
412 migrant women from ethnically diverse backgrounds, poor nutritional status is an
413 independent predictor of frailty. Given that weight loss may not necessarily be present
414 in community-dwelling older women, low energy and nutrient intakes make important
415 contributions to the development of frailty. Therefore, assessing dietary intake may
416 assist with screening for, and treating, frailty. Moreover, the mismatch found between
417 body weight and dietary inadequacy may potentially cause older women to engage in
418 self-imposed dietary restrictions that could cause further health problems. Future

strategies to prevent and detect frailty in this sub-group of the population should focus on maintenance of a healthy body weight as well as in the overall nutritional quality of the diet.

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573 **Table 1. Participant Demographic Characteristics**

Variable	Mean ± SD or % Total n=76	Mean ± SD or % Non-frail n=59	Mean ± SD or % Frail n=17	p values
Age (y)	70.5 ± 7.6	69.9 ± 6.5	74.1 ± 9.3	0.04
Residency in the UK (y)	38.73 ± 17.1	37.2 ± 17.8	44.1 ± 13.5	0.10
No. of diseases	2.3 ± 1.5	2.1 ± 1.5	3.3 ± 1.2	<0.001
Ethnicity, %				0.06
African-Caribbean	21 (27.6)	14 (23.7)	7 (41.2)	
African	10 (13.2)	10 (10.6)	0 (0)	
Arab	8 (10.5)	5 (8.5)	3 (17.6)	
Indian	20 (26.3)	17 (28.8)	3 (17.6)	
Pakistani	7 (9.20	6 (10.2)	1 (5.9)	
Bangladeshi	5 (6.6)	2 (3.4)	3 (17.6)	
Irish	5 (6.6)	5 (8.5)	0 (0)	
IMD quintile, %				0.20
1 (most deprived)	49 (64.5)	34 (57.6)	15 (88.2)	
2	11 (14.5)	10 (16.9)	1 (5.9)	
3	7 (9.2)	7 (11.9)	0 (0)	
4-5 (less deprived)	9 (11.8)	8 (13.6)	1 (5.9)	
Education, %				0.07
No qualifications	26 (34.2)	16 (27.1)	10 (58.8)	
Primary school	8 (10.5)	6 (10.2)	2 (11.8)	
Secondary school	18 (23.7)	15 (37.3)	3 (17.6)	
Tertiary	24 (31.6)	22 (37.3)	2 (11.8)	
Marital status, %				0.60
Married	34 (44.7)	31 (52.5)	3 (17.6)	

Widowed	30 (39.5)	21 (35.6)	9 (52.9)	
Single/ separated/divorced	12 (15.8)	7 (11.9)	5 (29.4)	
Living alone, %	26 (34.2)	20 (33.9)	6 (35.3)	0.60
BMI (kg/m^2)	29.3 ± 4.9	29.1 ± 4.8	30.2 ± 5.3	0.43
Normal, %	9 (11.8)	9 (15.3)	0 (0)	
Overweight, %	23 (30.3)	16 (27.1)	7 (41.2)	
Obese, %	44 (57.9)	34 (57.6)	10 (58.8)	
WC (cm) [a]	98.8 ± 10.8	97.8 ± 11.1	102.0 ± 9.3	0.15
WHR [a]	0.92 ± 0.8	0.92 ± 0.1	0.92 ± 0.6	0.70
Unintentional weight loss, %	9 (11.8)	6 (10.2)	6 (10.2)	0.41
Supplement use, %	30 (39.5)	24 (40.7)	6 (35.3)	0.46
Energy intake (Kcals)	1243.5 ± 524.4	1379.9 ± 507.9	819.7 ± 262.5	<0.01
Frailty score (No. of frailty components, %)				NA
0	36 (47.4)	36 (61)	0 (0)	
1	23 (30.3)	23 (39)	0 (0)	
≥2	17 (22.4)	0 (0)	17 (100)	

[a] n=68, BMI= Body Mass Index, IMD= Index of Multiple Deprivation, WC= waist circumference, WHR= waist-to-hip ratio, NA=not applicable.

Table 2. Association Between Frailty Syndrome and its Components According to the Number of Nutrients with Low Intake (n=76)

Number of nutrients with low intake				**Adjusted Odds Ratios [a]**	
Variables	0	1-3	>3	Low intake of 1-3 nutrients compared to 0	Low intake of >3 nutrients compared to 0
	%	%	%	OR (95% CI)	OR (95% CI)
Frailty	17.6	29.4	52.9	3.11 (0.56-17.35)	6.58 (1.01-43.08) [b]

syndrome					
Frailty components:					
Exhaustion	24.2	26.9	35.3	0.92 (0.26-3.17)	1.12 (0.17-7.20)
Low PA	9.1	19.2	47.1	2.30 (0.46-11.33)	5.26 (0.72- 38.10)
Weak grip strength	18.2	26.9	17.6	0.57 (0.15- 2.16)	1.23 (0.14-10.26)
Slow walking speed	6.1	15.4	47.1	0.85 (0.11-6.79)	1.86 (1.13-3.07) [b]

[a] Adjusted for low energy intake, age and number of diseases; [b] $p < 0.05$

Table 3. Frailty Syndrome Associated with Low Intake of Specific Nutrients (n=76)

	Frailty [b]
Nutrient intake [a]	**OR (95% CI)**
Protein (g/day)	0.76 (0.09-5.99)
Retinol (µg/day)	10.33 (1.55- 68.94) [c]
Vitamin D (µg/day)	0.96 (0.18-5.19)
Vitamin E (mg/day)	0.98 (0.17-5.68)
Vitamin C (mg/day)	3.82 (0.67-21.64)
Folate (µg/day)	0.78 (0.12- 5.06)
Calcium (mg/day)	3.87 (0.65-22.85)
Iron (mg/day)	0.94 (0.17- 5.19)
Zinc (mg/day)	8.47 (1.04-68.8) [c]

585 [a] Defined as the lowest quintile of each selected nutrient, [b] Adjusted for low energy

586 intake, age and number of diagnosed diseases, [c] $p<0.05$

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