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Original article

A new renal inpatient nutrition screening tool (Renal iNUT): a multicenter validation study

Helena S. Jackson [a, *], Helen L. MacLaughlin [b], Alberto Vidal-Diez [c], Debasish Banerjee [d]

[a] Renal and Transplantation Unit (Nutrition & Dietetics), St George's University Hospitals NHS Foundation Trust, Blackshaw Road, London SW17 0QT, UK
[b] Department of Nutrition and Dietetics, King's College Hospital, London SE5 9RS, UK
[c] Population Health Research Institute (PHRI), St George's, University of London, Cranmer Terrace, London SW17 0RE, UK
[d] Renal and Transplantation Unit, St George's University Hospitals NHS Foundation Trust, Cardiology Clinical Academic Group, Molecular and Clinical Sciences Research Institute, St George's University of London, Cranmer Terrace, London SW17 0RE, UK

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SUMMARY

Background: Screening of patients with renal disease for malnutrition risk on hospital admission provides an opportunity to improve prognosis. This study aimed to assess the validity and reliability of the Renal iNUT, a novel renal-specific inpatient nutrition screening tool.

Methods: Adult inpatient admissions to three renal units were screened using the Renal Inpatient Nutrition Screening Tool (iNUT) and the generic Malnutrition Universal Screening Tool (MUST) and compared against nutritional status using Subjective Global Assessment (SGA) as the standard. Construct validity was assessed by Handgrip Strength (HGS), reliability by repeated iNUT administration and nurse opinion by questionnaire.

Results: Of 141 admissions, 45% were malnourished (SGA score B or C). Using iNUT, 49% patients had increased malnutrition risk (score $\geq$1), 35.5% requiring dietetic referral (score $\geq$2). MUST indicated 20% at increased malnutrition risk and dietetic referral in 7%. iNUT was more sensitive than MUST in identifying increased malnutrition risk (92.1% vs 44.4%) and dietetic referral (69.8% vs 15.9%). Specificity of iNUT for increased risk was 82.1% and 92.3% for dietetic referral. 47% patients had sarcopenic-range HGS, with significant difference between iNUT score $\geq$2 and 0 ($p < 0.001$). iNUT reliability assessed by kappa was 0.74 (95% CI, 0.58 to 0.9), indicating substantial agreement. Nurse evaluation ($n = 71$) was highly favorable.

Conclusions: The Renal iNUT is a valid and reliable nutrition screening tool when used by nurses admitting patients to specialist renal wards. In comparison with MUST, use of iNUT is likely to improve the identification of malnourished patients for nutritional intervention and dietetic referral.

1. Introduction

Renal failure is characterized by a high prevalence of malnutrition. Causes include metabolic abnormalities, uremic symptoms such as anorexia and nausea, dialysis-specific factors, psycho-social factors, inflammation and comorbidities [1,2]. Hospitalization rates and length of stay are high in renal patients and more than 50% of patients admitted to a specialist renal ward may be malnourished [3–6]. Malnutrition is significantly associated with negative patient outcomes, including increased morbidity and mortality, with considerable additional economic cost [3,7–10]. Additionally, hospitalization itself increases the risk of malnutrition and its adverse effects and under-recognition of the condition impedes appropriate treatment [11–14]. The complexity of renal malnutrition and particular characteristics including fluid retention, dialysis-related fluid shifts, the protein energy wasting (PEW) syndrome and the coexistence of sarcopenia and obesity may further exacerbate under-diagnosis and treatment delay [1,2,15].

Renal dietitians have the specialist expertise to detect malnutrition in these patients. There are validated and recommended methods of nutritional assessment such as subjective global assessment (SGA) [16–18]. However, the completion of an individualized renal dietetic assessment or SGA for each admission

* Corresponding author.
E-mail addresses: helena.jackson@stgeorges.nhs.uk (H.S. Jackson), helen.maclaughlin@nhs.net (H.L. MacLaughlin), avidal.sgul@gmail.com (A. Vidal-Diez), Debasish.Banerjee@stgeorges.nhs.uk (D. Banerjee).

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requires a level of training, staffing and resources that may be inefficient and impractical for many renal inpatient wards. Nutrition screening is widely recommended to identify those at risk of malnutrition and to formulate an appropriate care plan for increased monitoring, intervention or dietetic referral [8,12,16,19]. A nutrition screening tool (NST) needs to be assessed for validity; in particular to ensure that it is in agreement with a comprehensive nutrition assessment, and for reliability in producing the same result when used by different operators [20–23].

The Malnutrition Universal Screening Tool (MUST) is a widely used, validated generic NST [8,9,12,19]. It comprises a score derived from body mass index (BMI: kg/m^2), weight loss and any acute disease with starvation for more than five days. There are advantages in using a single, simple tool across a broad range of healthcare settings, but validity may vary according to the intended user, patient group, setting and clinical purpose [22]. In a study of renal ward admissions, MUST did not identify malnutrition risk in almost half of patients with malnutrition according to SGA [5].

Due to the lack of a validated renal-specific NST for this patient group and to increase the number of malnourished patients correctly identified for nursing intervention and dietetic referral, the Renal Inpatient Nutrition Screening Tool (Renal iNUT) was developed for the specialist renal ward at St George's Hospital (SGH). The construction and scoring system of iNUT was based on MUST due to nursing staff familiarity with the generic tool. As with MUST, the iNUT categorizes patients into high (score $\geq$2), medium (score 1) and low risk (score 0) categories of malnutrition with appropriate action plan.

The low sensitivity of MUST when used in a renal inpatient population may be due to the complex and multifactorial nature of renal malnutrition. MUST screening acknowledges acute starvation but omits renal relevant risk factors such as anorexia and nutritional deficit [24,25]. Nutrition-related symptoms have been shown to have an important role in predicting malnutrition risk in renal patients with appetite recommended as a prognostic marker [26,27]. Therefore, in addition to measured weight, height, BMI and estimated weight loss, iNUT includes questions on appetite, intake, nutritional supplement use and renal-specific details on weight, utilizing the clinical expertise of the renal ward nurse (Fig. 1). The present study aimed to assess the validity and reliability of the iNUT and its viability as practical tool to identify malnutrition risk in patients admitted to the specialist renal wards of three UK National Health Service hospitals.

2. Materials and methods

2.1. Stage 1. Implementation of the renal iNUT

The Renal iNUT screening tool was introduced as part of routine nursing care for all admissions to the specialist renal wards at St Helier Hospital (SHH) and King's College Hospital (KCH) with a training package designed to be accessible, time-efficient and facilitate nurse-dietitian communication. At SGH, following three years of continuous iNUT use, a re-launch used the same strategy. Any pre-existing nutritional screening methods were discontinued.

2.2. Stage 2. Validation of the renal iNUT

A cross-sectional and longitudinal study was designed to assess the construct, concurrent and predictive validity, face validity and inter-rater reliability of the Renal iNUT and MUST in renal inpatients. UK Health Research Authority and individual institutional ethical approval were obtained, and the study conducted in adherence to the Declaration of Helsinki. A convenience sample of patients (aged > 18 years) was recruited from patients admitted under the care of a Consultant Nephrologist to the specialist renal wards of the three hospitals and included those with acute kidney injury, chronic kidney disease and on dialysis.

All eligible patients were given an information sheet about the study and written consent obtained. Exclusion criteria included patients with a planned admission of <24 hours and those unable to be assessed and given an SGA rating by the research dietitian within 48 hours of admission due to communication or other barriers. Data collection took place on weekdays only, between November 2015 and March 2016. The iNUT was completed by the nursing staff as part of routine admission protocol. Height and weight were measured using the standard MUST protocol [28]. Depending on patients' mobility and clinical condition, weights were measured in light indoor clothing without shoes using ward scales and heights were measured using a ward stadiometer and otherwise recorded from medical records or estimated using recommended procedures. The ward dietitian checked and recorded the iNUT score for all study patients.

2.3. Demographics and biochemistry

Age, gender, ethnicity, reason for admission, whether unplanned or planned and date of admission were recorded as well as the first routine serum albumin and C-reactive protein levels after admission. The Charlson Index score of co-morbidity was calculated from the documented medical history [29].

2.4. Concurrent and construct validity

Subjective Global Assessment (SGA) according to the method of Detsky and colleagues and undertaken by an experienced renal dietitian, was selected as the comparison reference standard for validation of the iNUT [17,18,30–32]. SGA combines a clinical dietetic interview and examination and is a recommended, validated method to categorize malnutrition status in renal patients. It was completed within 48 hours of admission by the research renal dietitian, who remained blinded to the result of the iNUT until after the completion of the study. SGA global classifications were used to categorize nutritional status (A – well-nourished, B – moderately malnourished, C – severely malnourished), and categories B and C were combined as a single group (malnourished) for analysis [30]. A standard hospital MUST form was completed by the research dietitian following hospital protocols prior to the SGA and handgrip assessments [28]. For the SGA, weights and heights were measured using ward equipment or recorded from a examination of paper and electronic medical records depending on patient mobility and clinical condition. Fluid-free weight was estimated from clinical examination in consultation with the medical team and weight change assessed from a clinical history and medical records.

Handgrip Strength (HGS) was measured by the research dietitian as an independent reference measure to assess construct validity. HGS is an objective non-invasive functional test of muscle strength and sarcopenia assessment, which correlates well with lean body mass and has prognostic value in renal patients [33–36]. The maximum value of up to three attempts (patient-led) from the dominant or, if applicable, cannula/fistula-free arm was selected. Patients were categorized as malnourished if maximum HGS was at least 2.5 standard deviations below the gender-specific peak mean (equating to female $\leq$16 kg, male $\leq$27 kg), which indicates sarcopenia, based on data from a large UK representative dataset of 50,000 subjects [37]. Fisher's exact test was used to test for differences in the proportion of patients with sarcopenic-range HGS in each of the MUST and iNUT categories.

The sensitivity and specificity, positive predictive value (PPV), negative predictive value (NPV) and kappa of the iNUT and MUST

Information to record
1. Admission weight (kg)
2. AND 'dry weight' i.e. most recent post dialysis or edema-free weight target (dialysis patients) OR reported usual weight (non-dialysis patients)
3. Height (m)
4. Body Mass Index (kg/m^2) using the lowest of the two weights documented

Admission screening questions	Scoring system
1 Has the patient unintentionally lost weight from their target OR usual weight?	No = 0, Yes = 1
2 Does the patient look malnourished OR have a BMI 20kg/m^2 or less?	No = 0, Yes = 1
3 Is the patient already on nutritional supplements?	No = 0, Yes = 1
4 Compared to usual, how is the patient's food intake?	better/similar = 0, worse = 1
5 Compared to usual, how is the patient's appetite?	better/similar = 0, worse = 1

Total score	Action Plan
0	Continue screening weekly
1	Monitor patient at risk (Local monitoring and nurse intervention protocols stated)
2 or more	Refer to dietitian (Local referral procedures stated)

Fig. 1. Outline structure of the Renal iNUT inpatient nutrition screening tool admissions page.

compared with the dietetic assessment using SGA were assessed according to the iNUT score and by categorizing patients as at risk or not at risk from malnutrition and using a contingency table to analyze the relationships between the tools. These were compared with the recommended target for sensitivity and specificity of above 80%, with 50–80% rated 'fair' and less than 50% as 'poor' [23].

2.5. Predictive validity

Length of admission and hospital re-admission within 30 days were recorded. Fisher's exact test was used to test for differences between the iNUT categories. For length of stay a Poisson regression with multiple variables following a forward selection method was used. A scale factor was added to correct for over-dispersion using Pearson's method. Orthagonal contrasts were carried out to assess for differences between the iNUT score categories.

2.6. Inter-rater reliability

Inter-rater reliability of the iNUT was tested in a subsample of consenting patients by completion of an additional iNUT within 48 hours of admission by a second administrator (ward nurse or dietitian), blinded to the initial iNUT form [5,21]. Weighted kappa was used to assess the level of agreement between the two assessments.

2.7. Face validity

All renal ward nurses were asked to answer a short questionnaire on ease of use and time taken to complete using a four-point Likert scale (to avoid central bias), and on nursing training, barriers, understanding and opinion of the iNUT, with an anonymous return option to reduce bias against unfavorable responses.

3. Results

In total 141 patients were included in the study (KCH, n = 42; SHH, n = 40; SGH n = 59). Median age was 64 (interquartile range IQR 52–74), 58 (41%) were female and 61% were non-elective admissions. Ethnic origin was 13% South-East Asian, 26% Afro-Caribbean, 57% White European, 4% Other. Other patient characteristics are shown in Table 1.

3.1. Concurrent and construct validity

According to SGA 55.3% inpatient admissions were well nourished (SGA category A) with 40.4% patients mildly to moderately malnourished (SGA category B) and 4.3% severely malnourished (SGA category C). In total 44.7% patients were malnourished (SGA categories B and C combined), rates at individual hospitals varying from 52.4% (KCH) to 42.5% (SHH) and 40.7% (SGH).

Table 1
Patient characteristics *(n = 141 unless otherwise stated).*

Variable	Median (Interquartile range)
Weight from SGA (kg) (weight adjusted for estimated fluid retention)	74.0 (64.5–85.0)
BMI from SGA (kg/m^2) (weight adjusted for estimated fluid retention)	25.7 (22.7–29.4)
Weight from MUST (kg) (weight as measured/from nursing records)	76 (65.5–90.5)
BMI from MUST (kg/m^2) (weight as measured/from nursing records)	26.2 (23.0–31.0)
Height (m)	1.70 (1.61–1.75)
Handgrip strength total (kg) *n = 138*	22 (17–30)
Handgrip strength women (kg) *n = 58*	18 (11–21)
Handgrip strength men (kg) *n = 80*	27 (21–37)
Albumin (g/L)	33 (27–37)
C-reactive protein (mg/L)	19 (4–56)
Length of stay (days)	3 (2–8)
Charlson Index	5.5 (3.0–7.0)

SGA: subjective global assessment, MUST: malnutrition universal screening tool. BMI: body mass index = weight (kg)/height^2 (m).

The number of patients identified with iNUT as requiring additional monitoring or intervention was more than twice that identified with MUST (Fig. 2).

The Renal iNUT identified 49.7% patients as low risk, and 35.5% requiring dietetic referral. MUST scored 80.1% patients as low malnutrition risk and indicated dietetic referral in 7.1% patients. The sensitivity of iNUT was highest at 92.1% for a score ≥1, i.e. when required to discriminate between no risk and increased risk. The MUST equivalent was 44.4%. iNUT sensitivity for a score ≥2 (referral to dietitian) was 69.8%, compared with 15.9% for MUST (Table 2).

In 47.1% of patients there was a sarcopenic-range HGS according to the Dodds criteria of below or equal to 27 kg (men) or 16kg (women). There was a significant difference in the proportion of sarcopenic-range HGS between the patients scoring 0 and those scoring ≥1 using iNUT ($p < 0.001$) and MUST ($p = 0.009$). When patients were grouped by whether a dietetic referral was indicated, there was significant difference using iNUT ($p < 0.001$) but no significant difference for MUST ($p = 0.31$) (Table 3).

3.2. Predictive validity

The most important predictor for length of stay was reason for admission, patients admitted as an emergency staying on average 3.0 days (95% CI: 1.8–4.8; p-value: <0.001) more than an elective admission. Orthogonal contrasts between iNUT scores concluded that patients with iNUT score ≥2 stayed on average 0.6 (95% CI: 0.4–0.8; p-value<0.001) days more than patients with iNUT score 0 or 1.

Readmission rate at 30 days was not different between the NUT ≥1 and iNUT = 0 groups (Fisher's exact test p = 0.6525). However, there were 7 deaths (10%) in the iNUT ≥1 group, including 6 during admission, and none in the iNUT = 0 group.

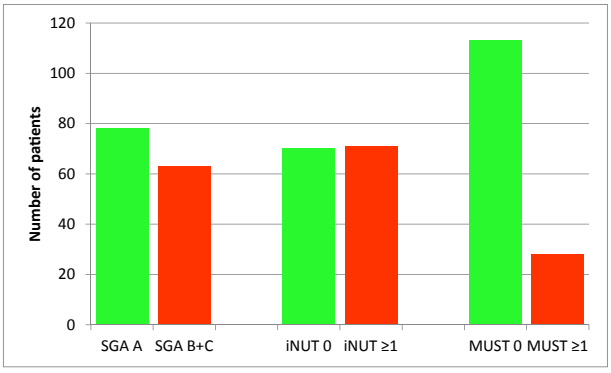

Fig. 2. Number of patients with increased nutritional risk score ≥1, as indicated by Renal Inpatient Nutrition Screening Tool (iNUT) and Malnutrition Universal Screening Toll (MUST), compared with nutritional status by Subjective Global Assessment (SGA). *(n = 141).*

3.3. Inter-rater reliability

Weighted kappa for the repeated iNUT assessments in a subsample of 50 subjects was 0.66 (95% CI, 0.52 to 0.81) for the scores 0 to 5 and 0.74 (95% CI, 0.58 to 0.89) for the action plan categories (0, 1, >1), indicating good and substantial agreement for both [23,38].

3.4. Face validity

The questionnaire was returned by 71 nurses, with individual hospital return rates of 52–86%. Experience in renal nursing was 0–27 years, median 4.5 years. 96% nurses reported iNUT to be 'easy' or 'very easy' to use and 96% completed the tool in 10 minutes or less. In total, 77% nurses reported receiving iNUT training, 97% that they felt confident in identifying the correct action plan and 92% that it was an appropriate tool for renal patients.

4. Discussion

In this study 45% admitted patients were malnourished according to SGA. This supports previous reports of high rates of malnutrition of 53% in comparable populations and highlights the importance of nutritional screening for the identification and treatment of malnutrition on specialist renal inpatient wards [5,6].

The iNUT identified 50% of all patients as being at increased risk of malnutrition, more than double the percentage identified with MUST. The sensitivity results suggest potentially large gains in the number of malnourished patients correctly identified for both increased monitoring and dietetic referral when using iNUT instead of MUST. The high specificity of 92% for an iNUT score ≥2 represents a small and clinically acceptable level of over-referral of well-nourished patients [23,39]. The reliability of iNUT was 'good' or 'substantial', particularly in terms of the clinical action plan indicated, and superior to reliability reported previously for MUST in one of the participating renal units [5,23,38]. Predictive validity was demonstrated in the significantly longer length of stay for patients identified as requiring dietetic referral by iNUT. These patients also had a significantly higher proportion of sarcopenic-range HGS compared with the low risk group, whereas there was no significant difference in the equivalent for MUST. In both the MUST and iNUT higher risk (score≥1) groups there was a significantly higher proportion of patients with poor HGS than the low risk group.

iNUT may be more sensitive than MUST in a renal inpatient population due to the inclusion of questions on recent appetite and intake as indicators of malnutrition rather than the MUST criterion of acute starvation. This is supported by studies indicating a role for appetite and other nutrition-related symptoms in screening for malnutrition risk in renal inpatients and outpatients [40,41]. Under-diagnosis of malnutrition by MUST may also be due to an over-reliance of the final score on measured weights with no discrimination between muscle, fat and fluid. BMI is a major component of MUST contributing to an elevated risk category in about 50% of cases [9]. Overhydration is common with renal failure and may mask muscle or fat depletion in individual patients [3]. However, Lawson and colleagues reported only a small mean (standard deviation) positive hydration of 1.8 (2.5) L in renal ward admissions

Table 2
The validity of the Renal Inpatient Nutrition Screening Tool (iNUT) and Malnutrition Universal Screening Tool (MUST) according to clinical outcome category, following comparison with subjective global assessment in a renal inpatient population (n = 141).

Clinical outcome category	Nutrition screening tool method by cut-off score	Sensitivity	Specificity	PPV	NPV	Kappa (95% CI)
Increased nutritional risk	Renal iNUT score ≥ 1	92.1%	82.1%	80.6%	92.8%	0.72 (0.60–0.83)
	MUST score ≥ 1	44.4%	100%	100%	69.0%	0.47 (0.34–0.60)
Refer to dietitian	Renal iNUT score ≥ 2	69.8%	92.3%	88.0%	79.1%	0.63 (0.51–0.76)
	MUST score ≥ 2	15.9%	100%	100%	59.5%	0.17 (0.07–0.27)

PPV positive predictive value; NPV negative predictive value; CI confidence interval.

Table 3
Sarcopenic-range hand grip strength for each test score category for the Renal iNUT and MUST *(n = 138)*.

	Nutritional screening tool score	Percentage (%) of patients with sarcopenic-range hand grip strength within each test score category (men≤27 kg, female≤ 16 kg)	HGS (Median (IQR))	p-value: Fisher's exact test
Increased nutritional risk	MUST low risk (MUST = 0)	41.4%	23 (18–31)	p = 0.0094
	MUST increased risk (MUST≥ 1)	70.4%	18 (12–22)	
	iNUT low risk (iNUT = 0)	32.8%	27 (20–37)	p = 0.0007
	iNUT increased risk (iNUT≥ 1)	60.6%	19 (14–25)	
Referral to dietitian	MUST no dietetic referral (MUST ≤2)	45.7%	23 (17–31)	p = 0.3060
	MUST dietetic referral indicated (MUST≥ 2)	66.7%	23 (17–31)	
	iNUT no dietetic referral (iNUT≤2))	33.7%	25 (19–34)	P < 0.0001
	iNUT dietetic referral indicated (iNUT≥ 2)	71.4%	18 (13–23)	

which had no effect on MUST score [5]. In the current study median (IQR) BMI 25.7 (22.7–29.4) kg/m^2 calculated from a clinical estimation of dry weight was well above the MUST and iNUT cut-off of 20 kg/m^2. Muscle mass was not assessed objectively in the current study, but HGS in 47% patients met diagnostic criteria for sarcopenia [37]. This is also consistent with prevalence rates of muscle wasting or sarcopenia of up to 44% reported in patients with advanced CKD, despite increasing overweight and obesity rates [15]. Similarly, in a study of 37,345 European hemodialysis patients mean (standard deviation) BMI was 26.0 (5.3) kg/m^2 and 47% patients had a low (<10th percentile) lean tissue index according to multi-frequency bioimpedance spectroscopy [42]. Fluid loading was noted to have only a limited effect on BMI in comparison to the altered relationship between fat and lean tissue. Therefore, the co-existence of high fat mass with muscle wasting, termed 'sarcopenic obesity', may be more of a factor contributing to the low sensitivity of MUST in this population.

A strength of this study is the acknowledgement of nurses as key stakeholders in malnutrition screening. A study achieving high sensitivity for a new renal-specific NST when completed by researchers reported low completion and compliance rates when introduced to nursing staff [6]. In the current study iNUT was completed by NHS hospital ward nursing staff within usual clinical roles to aim for a realistic scenario. Furthermore, due to the short time between implementation and study assessments at two sites, the majority were completed by nurses newly introduced to the iNUT following brief exposure to a standard, low-resource training package. This suggests that results for sensitivity, specificity and reliability are realistic and achievable in other specialist renal wards with similar time, staffing and financial constraints.

Additionally, the nurse opinion questionnaire had good return rates and reported a highly favorable evaluation of the iNUT. Nursing barriers to completion of MUST and other NSTs may include difficulty in accepting it as a nursing role, competing priorities, a lack of competence or confidence and a lack of concordance with their professional judgement [43,44]. The positive response of nursing staff to the iNUT, may be due to their direct experience of the superior sensitivity–specificity profile. In practice, the iNUT result may accord better with their professional clinical judgement and account for the high rates of reported clinical relevance which validates their expertise and improves confidence and prioritization of nutrition screening.

Study limitations include the convenience sampling and the nature of the consent procedure and assessments, which may have reduced participation from more acutely unwell, potentially more malnourished patients. However, the intra-subject comparisons of the screening tools and nutritional assessments should not be affected. The predictive validity of the iNUT was not fully demonstrated, with death a likely confounder for readmission within 30 days. A longer-term outcome period could be considered for future studies. A potential confounding effect on outcome is that of nutrition support appropriately initiated from successful screening, which was not assessed in this study. Patient opinion was not assessed but merits future examination as there is the potential and opportunity for a positive impact on completion and effectiveness of malnutrition screening through increased patient involvement [45].

5. Conclusion

The Renal iNUT is a valid, reliable and practical method of nutrition screening on admissions to specialist renal inpatient wards. The introduction of Renal iNUT for use in specialist renal wards is likely to be well accepted by nursing staff and increase the number of malnourished patients correctly referred for timely nutritional intervention. Further studies, including evaluation of outcome, completion rates and patient perspective are recommended.

6. CRediT authorship contribution statement

Helena Jackson: Conceptualization, Methodology, Investigation, Resources, Data curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project Administration, Funding Acquisition. **Helen MacLaughlin**: Conceptualization, Methodology, Validation, Writing – Original Draft, Writing – Review & Editing, Supervision, Funding Acquisition. **Alberto Vidal-Diez**: Methodology, Formal Analysis, Resources, Data curation, Funding Acquisition. **Debasish Banerjee**: Validation, Writing – Original Draft, Supervision. Funding Acquisition.

Statement of authorship

The authors have all made substantial contributions to the study design and revision and preparation of the manuscript, including final approval. Additional individual contributions are: Helena Jackson conceived the study, carried out the patient assessments and drafted the manuscript. Alberto Vidal-Diez provided statistical advice and undertook statistical analysis of the data. Debasish Banerjee and Helen MacLaughlin provided clinical and research supervision throughout the study.

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Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnu.2018.10.002

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