

FRAILKT: An observational cohort study comparing frailty assessment tools in adult waitlisted kidney transplant candidates

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Abstract

Background:

The 2020 KDIGO 'Clinical Practice Guideline on Evaluation and Management of Candidates for Kidney Transplantation' suggests frailty is measured when assessing a candidate's suitability to be waitlisted for a kidney transplant. However, the optimal method of frailty assessment is not clear. There are numerous frailty assessment tools, but it is uncertain if these instruments are capturing the same cohort of frail candidates or whether they are measuring different constructs. This study investigated frailty prevalence in a cohort of waitlisted kidney transplant candidates from the United Kingdom and Ireland, described factors associated with frailty and explored agreement between different frailty assessment tools.

Methods:

FRAILKT is a single-region observational cohort study of adult waitlisted kidney transplant candidates who had transplant procedures in Northern Ireland. Frailty was assessed in all candidates using four frailty assessment tools. Correlations were analysed using Spearman's test. Agreement between frailty classifications was analysed using Cohen's kappa.

Results:

190 participants were recruited. Frailty prevalence was measured by each of the tools (14.7% by Fried Frailty Phenotype, 16.8% by Edmonton Frail Scale, 9.5% by FRAIL scale and 11.0% by Clinical Frailty Scale). Factors associated with frailty depended on the tool used to measure it. Agreement between frailty assessment tools on a candidate's frailty status was limited. Fifty participants were classified as frail using the frailty assessment tools however only three participants were classified as frail by all four frailty instruments.

Conclusions:

Frailty prevalence in waitlisted kidney transplant candidates varies depending on the measurement tool used. The limited agreement between assessment tools suggests that they may be capturing different constructs. Establishing the optimal tool for assessing frailty in waitlisted kidney transplant candidates remains challenging.

INTRODUCTION

Frailty is a syndrome characterised by decreased physiological reserve and limited ability to respond to stressor events¹. Many of the factors which influence the decline to frailty are inherent in patients with advanced chronic kidney disease (CKD), including cellular senescence, chronic inflammation, physical inactivity and poor nutrition². It is therefore not surprising, that frailty is common in patients with Kidney Failure (KF), regardless of age, and is associated with adverse health outcomes including hospitalisation and mortality²⁻⁵.

Kidney transplantation is the optimal treatment for suitable adults with KF, offering improved survival, quality of life and lower costs compared to chronic dialysis therapy^{6,7}. This remains true in patients over 65 years old^{6,8–11}. Nevertheless, undergoing kidney transplantation is a physiological stress, particularly for older adults. Patients need to have the physiological reserve to cope with the stressors of surgery, anaesthesia and immunosuppression to gain the predicted survival and quality of life benefits from a kidney transplant compared to dialysis therapy. Identifying patients who have the physiological reserve to undergo kidney transplantation is challenging, with existing risk prediction models only having a c-statistic of 0.66–0.70 for predicting patient survival.¹² The concept of frailty is emerging as a potentially important risk factor for adverse outcomes in patients waitlisted for kidney transplantation, with KDIGO¹³ now suggesting that frailty assessment be part of the process of assessing a candidate's suitability for waitlisting.¹³ The basis for this level 2C recommendation is largely inferred from North American studies that show frailty is prevalent in the waitlisted population^{14–17}, and associated with adverse outcomes after kidney transplantation^{18–24}. However, data on the prevalence of frailty in waitlisted candidates in the United Kingdom and Ireland is limited and its association with outcomes after transplantation is even more sparse.

Although there is agreement amongst transplant professionals that frailty is conceptually important when considering a candidate's suitability to be waitlisted,²⁵ there is poor agreement on how it should be defined. Two main models of frailty have emerged in the scientific literature. Firstly, the phenotypic model, which views sarcopenia as the hallmark feature of frailty²⁶. Secondly, the cumulation of deficits model which views frailty as a state of deficit accumulation²⁷. From these two scientific models, upwards of 50 different frailty assessment tools have been developed in an attempt to operationalize frailty in clinical practice²⁸. The optimal method of frailty assessment to be used in evaluating candidates for waitlisting is not described in the 2020 KDIGO guideline.¹³ The Fried Frailty Phenotype (FP), which is based on the phenotypic model, is used to define frailty in the guideline. However, the Frailty Index (FI), which is based on the cumulation of deficits model is then referenced as the tool to be used. It is unclear whether these tools are simply different instruments capturing the same cohort of frail candidates, or whether they are measuring different constructs and capturing different patients altogether.

We conducted a prospective cohort study of waitlisted kidney transplant candidates with the following aims: (1) describe frailty prevalence in a cohort of waitlisted kidney transplant candidates using four assessment tools which have been shown to correlate with adverse outcomes in patients with KF; (2) identify patient characteristics associated with frailty by each measure and (3) determine the level of agreement between each of the measures.

METHODS

FRAILKT is a single-region, prospective observational cohort study being conducted at the Regional Nephrology and Transplant Unit, Belfast City Hospital, Northern Ireland. This centre provides kidney

transplant services to all patients in Northern Ireland and access to kidney transplantation via the United Kingdom (UK) Kidney Sharing Scheme for patients from the Republic of Ireland. Additionally, for patients undergoing live donor transplantation, if their donor lives in Northern Ireland, their transplant procedures can be undertaken in Northern Ireland.

Favourable ethical approval was received from the South Central – Hampshire A Research Ethics Committee and Health Research Authority (REC reference 22/SC/0434) and governance approval from institutional review board assessment by the Belfast Health & Social Care Trust (22049EC-SS).

Study Setting

Individuals aged 18 years or older listed to undergo kidney transplantation were invited to participate. Informed written consent was obtained from all recruited study participants.

Eligibility Criteria

Inclusion criteria included adults aged 18 years or older categorised as 'active' on the deceased donor kidney transplant waiting list in Northern Ireland or who were at an advanced stage of the live donor work-up (suitable donor identified and transplant procedure being planned) and ability to give informed consent. There were no exclusion criteria.

Baseline Assessment

All study activities were completed by the primary researcher at scheduled healthcare encounters (e.g. outpatient clinic appointments) to limit disturbances to participant's time. To reduce variation in physical and mental performance in relation to haemodialysis, frailty assessments for patients undergoing chronic haemodialysis were performed at least 24 hours following a haemodialysis session²⁹.

The baseline assessment consisted of completion of four frailty assessment tools (Fried Frailty Phenotype (FP),²⁶ the Edmonton Frail Scale (EFS),³⁰ the FRAIL scale³¹ and the Clinical Frailty Scale (CFS)³²). The FP and the FRAIL scale are largely based on the phenotypic model of frailty. The EFS and the CFS are largely based on the cumulation of deficits models of frailty. The frailty assessment tools were chosen as they are the most widely studied and utilised assessment methods of frailty in patients with KF.

The primary frailty assessment tool was the FP. The FP has been validated in KF and kidney transplant (KT) populations^{19,33}. It is based on five components: shrinking (self-report of unintentional weight loss > 5% in the past year based on dry weight), weakness (grip strength below an established cut-off based on sex and body mass index (BMI)), exhaustion (self-report), low activity (self-report) and slow walking speed (time to walk 15 feet below an established cut-off according to sex and height)²⁶. Each of the five components was scored as present (one) or absent (zero) and then summed. If a patient had a

haemodialysis vascular access site on their arm, hand grip strength was measured using both hands, with the highest result taken. The EFS is a multi-domain assessment tool which has been validated in a KF population³⁴. Two domains are assessed using performance-based items: the clock test for cognitive assessment and the ‘Timed Get Up and Go’ for balance and mobility. The other domains are self-reported: mood, functional independence, social support, nutrition, health attitudes, continence, burden of medical illness and quality of life³⁵. Each item was scored from zero to two and then summed. The FRAIL scale has been validated in community-dwelling adults and has been found to correlate with dialysis-related complications in patients with KF^{31,36}. It is comprised of five brief questions (fatigue, resistance, ambulation, loss of weight and co-morbidity). The questions are self-reported. Each item is scored as present (one) or absent (zero) and then summed. The CFS has been validated in KF and KT populations^{37,38}. It presents eight categories with increasing degrees of frailty and a ninth category for terminally ill patients³⁹. Following the baseline assessment, the primary researcher assigned each patient a CFS score. A visual summary of each of the frailty assessment tools is displayed in Table 1.

Table 1: Comparison of what each of the frailty tools measure

Characteristic	Physical Frailty Phenotype	Edmonton Frail Scale	FRAIL Scale	Clinical Frailty Scale
Fatigue	Self-report		Self-report	Self-report
Weight Loss	Measured	Self-report	Self-report	
Physical Activity	Self-report	Self-report	Self-report	Self-report
Grip Strength	Measured			
Gait Speed	Measured	Measured		
Cognition		Self-report		
Hospital Admissions		Measured		
Psychological wellbeing		Self-report		
Social Support		Self-report		
Continence		Self-report		
Co-morbidity		Measured	Measured	Self-report
Polypharmacy		Measured		

Key:

Phenotypic model

Cumulation of deficits model

Common to both

Frailty Definitions

All patients were classified at baseline with the following frailty definitions: FP range 0–5 (frail ≥ 3, vulnerable 1–2, robust 0) ²⁶, EFS range 0–17 (frail ≥ 8, vulnerable 6–7, robust 0–5) ⁴⁰, FRAIL scale range 0–5 (frail ≥ 3, vulnerable 1–2, robust 0) ³¹ and CFS range 1–9 (frail ≥ 5, vulnerable 4, robust 1–3)⁴⁰.

Additional Baseline Data

Baseline data were collected prospectively by the primary researcher including age, sex, ethnicity, body mass index (BMI), co-morbid conditions (cardiovascular disease, peripheral vascular disease, cerebrovascular disease, diabetes, prior solid organ transplantation), cause of KF, renal replacement therapy vintage (months), smoking status, Charlson Comorbidity Index, number of medications and number of hospitalisations in the past 12 months.

Statistical Analysis

All analyses were conducted using SPSS version 29.0.2.0 (IBM Corp., Armonk, NY). Participant characteristics were summarised using appropriate descriptive statistics. Differences between groups were compared using Chi-square or Fisher's exact tests for categorical variables (parametric or non-parametric data) and one-way ANOVA or Kruskal-Wallis test (parametric or non-parametric data) for continuous variables. Odds ratios were calculated using logistic regression. Correlations were analysed using Spearman's test. Agreement between frailty classifications were analysed using Cohen's kappa. Strength of agreement was rated as ≥ 0.81 -1.00 almost perfect, 0.61-0.80 substantial, 0.41-0.60 moderate, 0.21-0.40 fair and ≤ 0.01 -0.20 minimal⁴¹. Missing data were assumed to be missing at random and handled via listwise deletion. A p-value ≤ 0.05 was considered statistically significant for all analyses.

RESULTS

Between 14 January 2023 and 17 December 2024, 220 patients were screened. 190 participants were recruited to the study. Reasons for non-inclusion were inability to provide valid informed consent (n = 2), too unwell to complete the baseline assessment (n = 1), language barrier (n = 2), refusal to consent (n = 6) and lack of availability of the primary researcher to complete the baseline assessment (n = 19). The median age at recruitment was 54 years (inter-quartile range (IQR) 43-63). 5% of the cohort was male. 94.7% of the cohort was White. Table 2 summarises the baseline demographics of the cohort.

Table 2
Baseline demographics of the cohort

Characteristic		Total cohort	Participants classified as frail by			
			FP	EFS	FRAIL	CFS
N (%)		190	28 (14.7)	32 (16.8)	18 (9.5)	21 (11.0)
Age (median, IQR)		54 (43–63)	54 (45–62)	49 (43–60)	59 (48–62)	56.5 (46–68)
Female (n, %)		77 (40.5%)	12 (42.9)	14 (43.8)	6 (33.3)	7 (38.9)
BMI (median, IQR)		26.8 (23.1–31.1)	25.5 (23.0–30.8)	26.8 (23.4–32.7)	26.5 (23.7–31.2)	26.2 (22.7–31.1)
Cause of KF (n, %)	Glomerulonephritis	53 (27.9)	10 (35.7)	10 (31.3)	4 (22.2)	4 (22.2)
	Interstitial nephritis	9 (4.7)	0 (0)	0	0	1 (5.6)
	ADPKD	35 (18.4)	6 (21.4)	4 (12.5)	2 (11.1)	2 (11.1)
	DN	29 (15.3)	6 (21.4)	7 (21.9)	8 (44.4)	6 (33.3)
	Unknown	21 (11.1)	3 (10.7)	4 (12.5)	3 (16.7)	4 (22.2)
	Other	43 (22.6)	3 (10.7)	7 (21.9)	1 (5.6)	1 (5.6)
Modality (n, %)	Haemodialysis	61 (34.2)	12 (42.9)	12 (37.5)	8 (44.4)	10 (55.6)
	PD	26 (13.7)	3 (10.7)	2 (6.3)	1 (5.6)	2 (11.1)
	CKD 5	75 (39.5)	8 (28.6)	11 (34.4)	9 (50)	4 (22.2)
	Tx-HD	14 (7.4)	2 (7.1)	2 (6.3)	0 (0)	0 (0)
	Tx-PD	5 (2.6)	1 (3.6)	2 (6.3)	0 (0)	0 (0)
	Tx-CKD 5	9 (4.7)	2 (7.1)	3 (9.4)	0 (0)	2 (11.1)
RRT Vintage (median, IQR (months))		2.5 (0–19)	2.5 (0–19)	5.5 (0–20.5)	4.5 (0–14.5)	10.5 (0.8–

Results presented as n (%) unless otherwise stated. IQR – interquartile range, BMI: Body mass index, KF – Kidney Failure: End-Stage Kidney Disease, ADPKD: Autosomal dominant polycystic kidney disease, DN: Diabetic Nephropathy, CKD 5: Chronic kidney disease stage 5, Failed Tx – HD: failed transplant on haemodialysis, Failed Tx – PD: failed transplant on peritoneal dialysis, Failed Tx – CKD 5: failed transplant chronic kidney disease stage 5, IQR – interquartile range, RRT: renal replacement therapy, FP – Fried Frailty Phenotype, EFS – Edmonton Frail Scale, CFS – Clinical Frailty Scale

Characteristic		Total cohort	Participants classified as frail by			
			FP	EFS	FRAIL	CFS
						23.5)
Previously transplanted (n, %)		30 (15.8)	6 (21.4)	9 (28.1)	1 (5.6)	3 (16.7)
Number of hospital admissions in the past year (median, IQR)		0 (0–1)	0 (0–1)	1 (0.25–2)	0 (0–1.25)	1 (0–1.25)
Charlson comorbidity index score (median, IQR) (range 0–29)		4 (2–4)	4 (2–4)	3 (2–4)	4 (3.75–5.25)	4 (3.8–5.3)
Co-morbidity (n, %)	Cardiovascular disease	10 (5.3)	0 (0)	0 (0)	1 (5.6)	0 (0)
	Cerebrovascular disease	8 (4.2)	1 (3.6)	0 (0)	1 (5.6)	0 (0)
	Diabetes	34 (17.9)	8 (28.6)	8 (25)	8 (44.4)	6 (33.3)
	Peripheral vascular disease	6 (3.2)	2 (7.1)	2 (6.3)	2 (11.1)	1 (5.6)
Smoking Status	Non-smoker	121 (63.7)	17 (60.7)	18 (56.3)	9 (50)	7 (38.9)
	Ex-smoker	46 (24.2)	7 (25)	9 (28.1)	7 (38.9)	7 (38.9)
	Current smoker	23 (12.1)	4 (14.3)	5 (15.6)	2 (11.1)	4 (22.2)
Number of prescribed medications		8 (6–11)	8 (6–11)	11 (7.25–13)	11 (8.75–13)	12 (8.75–14.5)
Results presented as n (%) unless otherwise stated. IQR – interquartile range, BMI: Body mass index, KF – Kidney Failure: End-Stage Kidney Disease, ADPKD: Autosomal dominant polycystic kidney disease, DN: Diabetic Nephropathy, CKD 5: Chronic kidney disease stage 5, Failed Tx – HD: failed transplant on haemodialysis, Failed Tx – PD: failed transplant on peritoneal dialysis, Failed Tx – CKD 5: failed transplant chronic kidney disease stage 5, IQR – interquartile range, RRT: renal replacement therapy, FP – Fried Frailty Phenotype, EFS – Edmonton Frail Scale, CFS – Clinical Frailty Scale						

Prevalence of frailty by instrument

Figure 1 illustrates the prevalence of frailty in the cohort as determined by the four frailty assessment tools. Fifty participants across the cohort were categorised as frail. The median FP was 1 (IQR 1–2) with 28 (14.7%) participants classified as frail, 123 (64.7%) as vulnerable and 37 (19.5%) as robust. Self-reported exhaustion was the most common FP impairment (53.2%) (see table S1). The median EFS was 5 with 32 (16.8%) participants classified as frail, 41 (21.6%) as vulnerable and 114 (60%) as robust. The median FRAIL scale was 1 (IQR 0–1) with 18 participants (9.5%) classified as frail, 102 (53.7%) as vulnerable and 70 (36.8%) as robust. The median CFS was 3 (IQR 3.00–3.25) with 21 participants (11.0%)

classified as frail, 26 (13.6%) as vulnerable and 143 (75.3%) as robust. Frailty was prevalent in those under the age of 65, with 25 (16.0%) of 156 participants classified as frail by FP, 29 (18.6%) by EFS, 16 (10.3%) by the FRAIL scale and 13 (8.3%) by the CFS.

Association between frailty and key demographics

Table 2 summarises the baseline demographics of participants classified as frail by each tool. Participants who had been previously transplanted were more likely to be classified as frail by the EFS (odds ratio (OR) 3.25 (1.34–7.91), $p = 0.009$). When adjusted for age, sex, BMI and presence of diabetes, this association remained statistically significant (adjusted odds ratio (aOR) 4.18 (1.56–11.22), $p = 0.004$). Participants with diabetes were more likely to be classified as frail by the FRAIL scale (OR 4.49 (1.62–12.45), $p = 0.004$). This remained statistically significant following adjustment for age, sex and BMI (aOR 4.70 (1.61–13.80), $p = 0.005$). Participants classified as frail by each of the four tools had a higher median number of prescribed medications compared to those classified as vulnerable or robust (FP frail 10.5 (7.0–12.8) vs. vulnerable 10.5 (7.0–12.8) vs robust 8.0 (6.0–10.0) ($p = 0.05$), EFS frail 11.0 (7.3–13.0) vs. vulnerable 9.0 (6.5–13.5) vs robust 7.0 (5.0–10.0) ($p < 0.001$), FRAIL scale frail 11.0 (8.8–13.0) vs. vulnerable 9.0 (6.0–11.0) vs robust 7.5 (6.0–10.0) ($p = 0.007$), CFS frail 12 (8.8–14.5) vs vulnerable 9.0 (6.0–12.6) vs. robust 8.0 (6.0–10.0) ($p = 0.004$).

Correlation and agreement between frailty assessment tools

Correlation of raw frailty scores was best between the FP and the FRAIL scale (Spearman's rho 0.57, $p < 0.001$). Correlation was poorest between the FP and the CFS (Spearman's rho 0.42, $p < 0.001$). When the assessment tools were used to classify participants as frail, vulnerable or robust, agreement between the assessment tools was fair at best. (see Fig. 2). Only three participants were classified as frail using all four instruments (see Fig. 3).

DISCUSSION

FRAILKT is a large prospective cohort study of waitlisted kidney transplant candidates, comparing different methods of frailty assessment with linkage to long-term outcomes. In our first analysis, we have described the prevalence of frailty, clinical factors associated with frailty and assessed the correlation and agreement between frailty assessment tools.

The prevalence of frailty in our cohort differed significantly depending on which frailty assessment tool was used. The prevalence of frailty by the FP (14.7%) in our cohort was in keeping with that reported in previous studies using FP to assess frailty in waitlisted kidney transplant populations^{17,38}. The prevalence of frailty by the EFS (16.8%) in our cohort was similar to that reported in the KTOP study, which assessed frailty in kidney transplant candidates over 65 years (using the EFS¹⁶). Given our study was not limited to older adults and included those aged between 18 and 65, our findings of similar

overall frailty prevalence suggest that in patients with KF, frailty is not primarily a syndrome of ageing. However, our patient cohort had already been approved for listing for transplantation, and so older patients with clinically apparent frailty (judged subjectively by their clinician) may not have been captured by this study (as they may not have been approved for waitlisting). Regardless, in keeping with many previously reported studies on frailty and KF^{18,40}, the burden of frailty remains significant in those under 65 years. The prevalence of frailty, determined by the FRAIL scale (9.5%) and the CFS (11.0%), was significantly lower than that of the FP and EFS. The FRAIL scale is entirely self-reported. Patients may have under-reported their symptoms of fatigue or over-reported their mobility or ability to climb stairs if they deemed this to have an impact on their chances of receiving a kidney transplant. The CFS relies entirely on the subjective judgement of a clinician to assess a patient's frailty. Objective markers of frailty such as reduced grip strength, or reduced walking speed, may be under-represented by using this tool to assess patients.

Clinical factors associated with frailty varied depending on the frailty assessment tool used. However, patients classified as frail by each of the four tools were all prescribed a higher number of medications compared to the vulnerable and robust patients. Polypharmacy is a domain of the EFS which may explain its association using this frailty instrument tool. However, its association with frailty as classified by the FP, FRAIL scale and the CFS, which do not include a measure of polypharmacy, suggests otherwise. This is in keeping with evidence on the association of frailty and polypharmacy in the general population⁴². There are potential explanations for this association. Polypharmacy may be a causal factor in the development of frailty, a symptom of having frailty, a measure of reduced psychological resilience reflecting dependence on medications, and plausibly a better overall capture of co-morbidity than traditional measures such as the Charlson co-morbidity index. The presence of diabetes was associated with frailty as classified by the FRAIL scale. Co-morbidity is included in the FRAIL scale measurement which may partly explain the association, however, the relationship between frailty and diabetes is recognised⁴³. Prior solid organ transplantation was associated with frailty as classified by the EFS. This is unsurprising given the high prevalence of frailty that has been reported in recipients of solid organ transplants⁴⁴⁻⁴⁶. Reasons for this may include the higher burden of co-morbidity and the effects of long-term immunosuppression in such patients.

Correlation between raw frailty scores was moderate at best. When instruments were used to classify patients as frail, vulnerable or robust, agreement between assessment tools was fair at best. This suggests that a high proportion of patients were classified differently depending on what tool was used to measure frailty. The substantial difference in the prevalence of frailty per tool that was observed in this cohort is illustrated in Fig. 1. This finding is unsurprising given the variety of parameters that each tool uses to diagnose frailty (see Table 1). However, despite the FP and FRAIL scale being assessment tools constructed based on the phenotypic model, with the largest number of shared items used in their measurements (see Table 1), agreement between the tools was only fair (κ 0.303). This is in keeping with data from a Spanish cohort of waitlisted kidney transplant candidates with a κ co-efficient in their cohort of 0.317⁴⁷. As described above, the self-reported nature of the FRAIL scale may account for this

difference. Correlation between the FP and CFS was minimal. Although this is not consistent with published work in community dwelling older adults⁴⁸, it has been previously reported in a waitlisted kidney transplant candidates from Canada with a κ co-efficient in their cohort of only 0.27³⁸. This may, in part, be related to the severity of frailty observed in waitlisted transplant candidates. These candidates have been assessed as being fit enough to undergo transplantation and, therefore, despite patients being classified as frail by the FP, they are conceivably 'fitter' than those who are classified as frail in the general population. Perhaps the FP is capturing vulnerability at a much earlier stage than the CFS can.

It is unclear if these different tools are capturing different stages of frailty, or different phenotypes altogether. In terms of prognostication, which tool is superior at predicting adverse long-term outcomes for waitlisted kidney transplant candidates, is unclear at this stage.

This study has several strengths. Bias has been limited by its prospective nature and the fact that all frailty assessments were completed by the primary researcher. Candidates of all ages have been included, allowing conclusions to be drawn for all adult waitlisted kidney transplant candidates. Multiple different frailty assessment tools which are used to predict outcomes in adults undergoing kidney transplantation, have been assessed prospectively to evaluate their utility in the transplant evaluation process. This is in line with the research recommendations from the 2020 KDIGO 'Clinical Practice Guideline on Evaluation and Management of Candidates for Kidney Transplantation'.¹³ However, given the study is from a single region with a majority White population its applicability is limited in other populations with more diverse ethnic and racial backgrounds.

In summary, frailty is prevalent in patients waitlisted for kidney transplantation, however, prevalence varies depending on the tool used to measure it. Factors associated with frailty again differ depending on the measurement tool. Agreement between tools is limited suggesting tools may be capturing different degrees of frailty, or different phenotypes altogether. In view of our findings, we urge caution in assessing frailty until consensus is reached amongst transplant professionals about which frailty assessment tool is optimal for use. Individual transplant centres employing different frailty assessment tools may result in wide variations in the diagnosis of patient frailty. This could result in an unintended inequity of access to transplant for patients with KF.

Abbreviations

ADPKD: Autosomal Dominant Polycystic Kidney Disease

aOR: Adjusted Odds Ratio

BMI: Body Mass Index

CFS: Clinical Frailty Scale

CKD: Chronic Kidney Disease

CKD 5: Chronic Kidney Disease Stage 5

DN: Diabetic Nephropathy

EFS: Edmonton Frail Scale

FI: Frailty Index

FP: Fried Frailty Phenotype

IQR: Interquartile Range

KF: Kidney Failure

KT: Kidney Transplant

OR: Odds Ratio

PD: Peritoneal Dialysis

RRT: Renal Replacement Therapy

Tx-CKD 5: Failed Transplant Chronic Kidney Disease Stage 5

Tx-HD: Failed Transplant on Haemodialysis

Tx-PD: Failed Transplant on Peritoneal Dialysis

Declarations

Ethics approval and consent to participate

Favourable ethical approval was received from the South Central – Hampshire A Research Ethics Committee and Health Research Authority (REC reference 22/SC/0434) and governance approval from institutional review board assessment by the Belfast Health & Social Care Trust (22049EC-SS). Informed written consent for data to be used in this study was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable

Availability of data and materials

Anonymized data is available upon request to the corresponding author. This is not publicly shared as clinical information is contained.

Competing Interests

The authors of this manuscript have no conflicts of interest to disclose as described by *BMC Nephrology*.

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Authors' Contributions

RCJF: Study concept and design, data collection, statistical analysis, interpretation of data, drafting of the manuscript, final approval of version to be published.

APM: Study concept and design, interpretation of data, critical revision of the article, final approval of version to be published.

ELC: Study concept and design, interpretation of data, critical revision of the article, final approval of version to be published.

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Figures

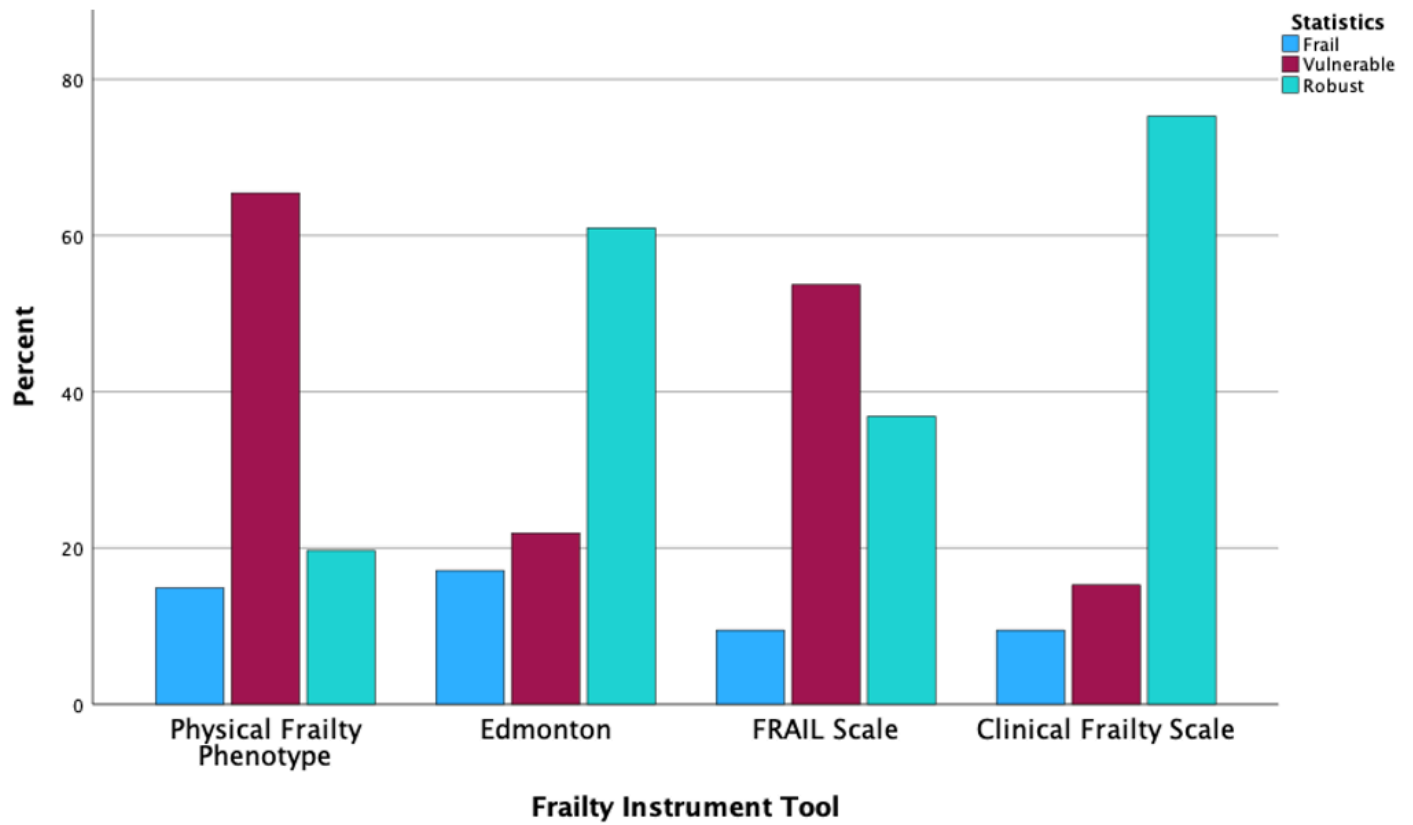


Figure 1

Percentage of patients characterised as frail, vulnerable and robust by each frailty assessment tool

	Fried Frailty Phenotype	Edmonton Frail Scale	FRAIL Scale	Clinical Frailty Scale
Fried Frailty Phenotype		0.135	0.303	0.091
Edmonton Frail Scale			0.166	0.328
FRAIL Scale				0.159

- Almost perfect >0.80 
- Substantial 0.61-0.80 
- Moderate 0.41-0.60 
- Fair 0.21-0.40 
- Minimal <0.20 

Cohen's Kappa

All results significant at $p < 0.001$

Figure 2

Heat map illustrating agreement between frailty assessment tools

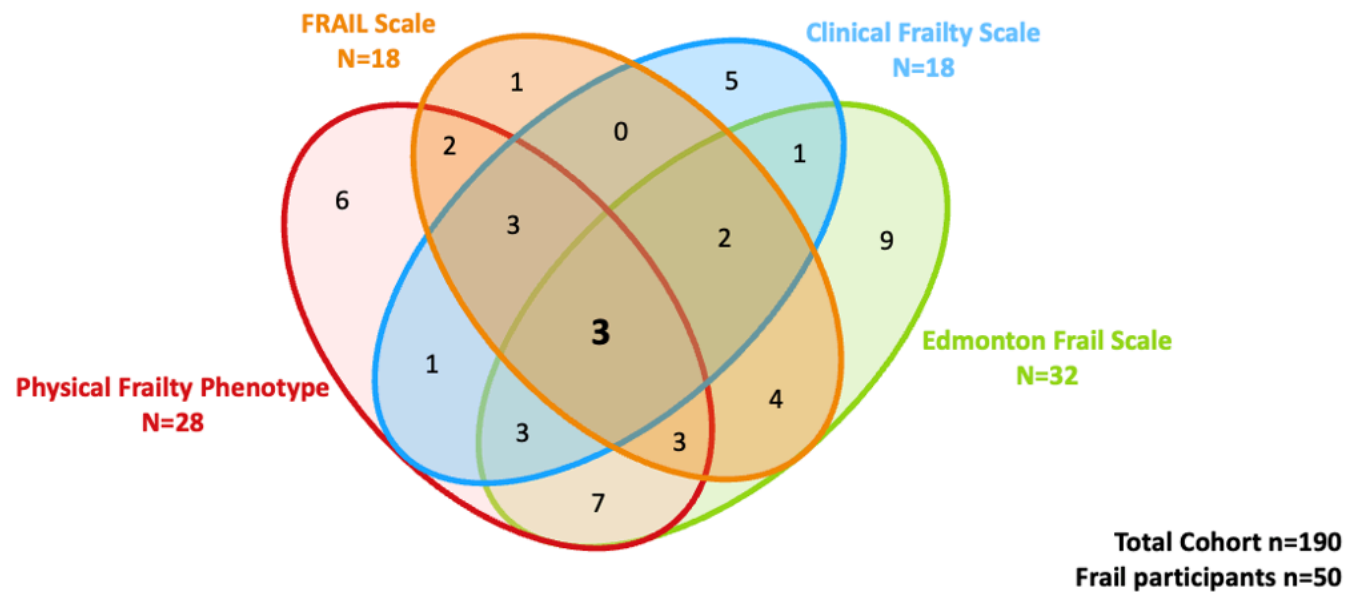


Figure 3

Venn diagram illustrating number of patients classified as frail by each instrument and their overlap

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