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Using human-robot interaction to assess emotion recognition in dialysis patients: A preliminary study

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ABSTRACT

This cross-sectional observational study examined the relationship between psychological factors and multi-modal emotion recognition abilities in patients with chronic kidney disease (CKD), introducing a humanoid robot as an innovative assessment modality. Sixty adults undergoing dialysis and awaiting renal transplantation (63.3 % male; mean age = 53.95 years, range 20–80) completed three emotion recognition tasks based on Ekman facial expressions, dynamic video clips, and emotional displays performed by the NAO humanoid robot, together with validated measures of alexithymia (TAS-20), anxiety (GAD-7), and depression (PHQ-9). Regression analyses showed that performance on the Ekman task was positively predicted by education and anxiety levels (β =.26, p = .037; β =.26, p = .043). Recognition of emotions in videos was negatively predicted by age (β = –.45, p < .001) and alexithymia (β = –.37, p = .002). For the robot-based task, increasing age (β = –.30, p = .020) and longer dialysis duration (β =.31, p = .017) significantly predicted recognition accuracy. Logistic regression analyses indicated that alexithymia negatively predicted recognition of disgust in videos and fear expressed by the robot. Levels of anxiety positively predicted recognition of happiness and fear in the Ekman test. Across the modalities, alexithymia and age emerged as core factors associated with reduced emotion recognition, with video and robot-based tasks capturing these differences more clearly than static facial stimuli. These findings suggest that socially assistive robots may represent a promising tool for detecting subtle socio-emotional processing alterations in medically vulnerable populations, supporting future longitudinal research integrating technological and psychological assessment.

1. Introduction

The ability to correctly recognize and interpret emotions is an essential component of social cognition and psychological functioning. It plays a crucial role in interpersonal interactions, influencing the quality of relationships and emotional well-being. Several studies have shown that difficulties in recognizing emotions are related to psychopathological conditions such as anxiety and depression, suggesting that alterations in emotional processing may contribute to the development or maintenance of these conditions (Mitchell and Phillips, 2015; Baez et al., 2023; Monferrer et al., 2023; Wheeler and Steinman, 2025).

In patients with chronic renal failure undergoing dialysis, the emotional and psychological burden of the disease can significantly affect their ability to process emotional stimuli. Dependence on continuous medical treatment, limitations in quality of life, and uncertainty about the future can contribute to increased psychological stress and impaired cognitive and emotional functions (Cukor et al., 2007). Several studies have reported a high prevalence of anxiety and depression in this population, negatively impacting their overall health and adherence to therapies (Palmer et al., 2013). In this context, difficulties in recognizing and regulating emotions may represent an additional vulnerability factor for these patients, influencing their psychological well-being and ability to face the challenges posed by the disease.

Beyond psychological distress, neurocognitive alterations typical of

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chronic kidney disease may contribute to emotion recognition difficulties. Neuroimaging and neuropsychological studies have demonstrated fronto-subcortical dysfunctions, executive impairments, and cognitive slowing in hemodialysis patients (O'Lone et al., 2016). Furthermore, cognitive fatigue and reduced mental flexibility—commonly reported in this population—may limit attentional resources and the ability to interpret complex emotional cues (Murray et al., 2006). These findings suggest that emotion recognition problems in dialysis patients arise from an interplay of psychological and neurocognitive factors rather than from psychological distress alone. Emotion recognition is traditionally studied through the analysis of facial expressions and behavioral responses. Ekman's theories highlighted the existence of universal emotions, recognizable through distinctive facial signals regardless of cultural background (Ekman and Friesen, 1976).

Clinically, alexithymia—difficulty in identifying and describing emotions—is common among dialysis patients and is associated with poorer psychological and physical outcomes (Ramya et al., 2024; Sun et al., 2025).

An emerging area of research focuses on the use of advanced technologies to study emotional skills, including humanoid robots in experimental settings (Conti et al., 2019). Indeed, robots capable of expressing emotions through movement and voice modulation offer new perspectives for understanding difficulties in emotion recognition and could provide innovative tools for targeted rehabilitation interventions (Beck et al., 2012; Conti et al., 2017; Takahashi et al., 2021).

Crucially, the role of social robots in emotion recognition and rehabilitation should be framed within established cognitive and psychological theories rather than viewed purely as technological novelties. From the perspective of embodied cognition, robots provide a unique platform to study how bodily states and sensorimotor experiences influence emotional understanding (Barsalou, 2008; Pfeifer and Bongard, 2007). By engaging patients in interactive, physically situated tasks, robots can elicit and modulate emotional responses in ways that are grounded in bodily experience, supporting the idea that cognition is not solely brain-bound but distributed across perception, action, and environment.

Multimodal integration is another key framework for Human Robot Interaction (HRI). Emotion recognition relies on the simultaneous processing of multiple cues, including facial expression, voice prosody, and body gestures (de Gelder and Vroomen, 2000). Social robots equipped with multimodal communication channels allow researchers to investigate how humans integrate these cues in real-time interactions, and how impairments in this integration affect emotion processing. For example, robotic platforms can be programmed to present congruent or incongruent multimodal emotional signals, enabling controlled studies on perceptual and cognitive mechanisms underlying emotional recognition deficits.

Finally, Theory of Mind (ToM) provides an essential lens for understanding HRI in emotional contexts. The capacity to attribute mental and emotional states to others is central to social cognition (Premack and Woodruff, 1978). Interaction with social robots, especially those exhibiting human-like emotional behaviors, allows patients to practice and refine ToM skills in a controlled, low-stakes environment. Research indicates that engaging with emotionally expressive robots can enhance empathic understanding and perspective-taking, with potential benefits for populations with social cognitive deficits (Scassellati, 2002; Marchetti et al., 2025).

Taken together, these theoretical frameworks suggest that social robots are not merely tools for technological demonstration, but active participants in embodied, multimodal, and socially grounded processes that support emotion recognition and regulation. Their use in clinical populations, including dialysis patients, offers a promising avenue to investigate and remediate emotional processing difficulties within a rigorously structured cognitive and social context, where patients with chronic kidney disease often exhibit difficulties in emotion recognition and regulation that negatively affect psychological well-being and quality of life.

Specifically, traditional paradigms, based on static photographs or video clips, fail to capture the complexity of social interactions or the multimodality of emotional signals. These limitations highlight the need for innovative approaches that can assess emotional processing in ecologically valid and interactive contexts. The use of social robots allows for the presentation of dynamic, interactive, and standardized emotional stimuli, providing a platform to investigate the underlying cognitive mechanisms in clinical populations such as dialysis patients.

1.1. *Study objectives and rationale*

The present study aims to investigate emotion recognition abilities in patients with chronic kidney disease undergoing dialysis. Given the high prevalence of anxiety, depression, and alexithymia in this population, understanding how these factors relate to emotional processing could be essential for guiding the development of effective psychological interventions.

This study specifically aims to evaluate emotion recognition performance in dialysis patients through an interactive and multimodal robotic paradigm. Furthermore, it investigates potential associations between emotion recognition, alexithymia, anxiety, and depression in this population. Lastly, it examines the feasibility of using socially expressive robots as experimental tools for the assessment of emotional processing in clinical contexts. By addressing these aims, the study seeks to lay the groundwork for future interventions targeting emotional rehabilitation and psychological support in dialysis patients.

1.2. *Alexithymia in patients undergoing dialysis*

Nemiah and Sifneos (1970) conceptualized alexithymia as a psychological deficit in affective processing. Alexithymic individuals typically exhibit difficulties in identifying, understanding, and regulating their emotions (Farhoumandi et al., 2021; Sifneos, 1973).

Over the past fifty years, empirical research on alexithymia has progressively expanded, and the construct has become increasingly integrated into the broader framework of emotional and affective regulation (Preece et al., 2024).

Besides being a relatively stable personality trait, alexithymia may also emerge as a secondary phenomenon, as a reactive state resulting from particularly stressful moments (such as dialysis) and as a defense mechanism ("emotional anesthesia") against one's own emotional discomfort during critical life periods. In this context, "emotional anesthesia" would serve an adaptive purpose by shielding the individual's inner reality of suffering and failure (Lumley et al., 2007).

Recent findings suggest that alexithymia may play a significant role in the treatment and clinical outcomes of patients undergoing dialysis. Research has examined both the prevalence of alexithymia in this population and its correlations with physical and psychological health variables. Moreover, higher levels of alexithymia tend to be observed in patients with a greater number of comorbid conditions (Ramya et al., 2024; Pistorio et al., 2017).

Recent studies have also explored how clinical and psychopathological factors can modulate this ability, suggesting that conditions such as anxiety and depression can alter emotional processing and reduce accuracy in recognizing emotional expressions (Preece et al., 2024; Lanzara et al., 2020).

Our study aims to investigate the ability to recognize emotions in a sample of dialysis patients awaiting transplantation and to explore the correlation between this ability and levels of anxiety and depression. Insights into these aspects could contribute to a better understanding of the psychological difficulties faced by these patients and to the development of support strategies aimed at improving their quality of life.

2. Materials and methods

2.1. Participants and recruitment

The study involved 66 dialysis patients awaiting transplantation, recruited from the outpatient clinic of [omitted for review]. The final sample comprised 60 participants: 38 males (63.3 %) and 22 females (36.7 %), aged 20–80 years (mean age = 53.95, SD = 12.02). None of the participants had prior experience with social or humanoid robots. All provided informed consent before participation, and the study was approved by [omitted for review]. It followed a cross-sectional observational design, with all measures collected during a single session conducted while patients were undergoing dialysis.

2.2. Stimulus material

The NAO social robot was used as the experimental stimulus. NAO is a humanoid robot, 58 cm tall and weighing 5.2 kg, developed by Aldebaran (France), with documented safety features. It was programmed using Choregraphe software and the Python 2.7 + SDK within the NAOqi 2.5 framework. NAO's 25 ° of freedom—including joints in the arms, hands, legs, head, and hips—enable it to perform emotional expressions through body gestures, sounds, and changes in LED eye colour.

2.3. Instruments

2.3.1. Facial Action Coding System (FACS)

The Facial Action Coding System (FACS; Ekman and Friesen, 1976) is an anatomically based method for identifying 44 independent facial muscle movements (Action Units, AUs) based on functional anatomy. FACS can describe any facial behaviour, not limited to emotions. It codes the presence, intensity, laterality, and timing of muscle actions, providing detailed analysis, although it is complex and labour-intensive.

2.3.2. Emotion elicitation movie clips

According to the literature, film excerpts are widely used to elicit emotional states in both adults (Gross and Levenson, 1995) and children (Cirasa et al., 2024; Von Leupoldt et al., 2007). Following this approach, participants in the present study were shown six short clips from Disney movies, presented in randomized order. The procedure, adapted from Tsiourti et al. (2019), employed video stimuli that had been pre-tested in an independent, demographically balanced sample of 70 adults, confirming their effectiveness in eliciting distinct basic emotions.

2.3.3. Emotion recognition of NAO robot

The robot's emotional responses were programmed using the Choregraphe application. Since NAO's face is static, body language and LED colour serve as the primary channels of communication. The selected emotions for the robot were inspired by Beck et al. (2010). Specifically, anger, happiness, and sadness had been previously used in a study by [omitted for review]. To cover the full range of basic emotions, three additional emotions—disgust, fear, and surprise—were incorporated into the present study (see Fig. 1).

2.3.4. Toronto Alexithymia Scale (TAS-20)

The TAS-20 (Taylor et al., 2003) is a widely used self-report questionnaire assessing alexithymia—a difficulty in identifying, describing, and understanding emotions. It consists of 20 items rated on a five-point Likert scale, measuring three dimensions: difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Scores categorize individuals according to alexithymia severity. The TAS-20 has strong psychometric support and is frequently used in both clinical and research settings.

2.3.5. Patient Health Questionnaire (PHQ-9)

The PHQ-9 (Kroenke et al., 2001) screens for depression severity based on nine DSM-IV criteria. Participants rate symptom frequency over the past two weeks on a scale from "not at all" to "nearly every day," resulting in a total score ranging from 0 to 27. Scores of 10 or higher

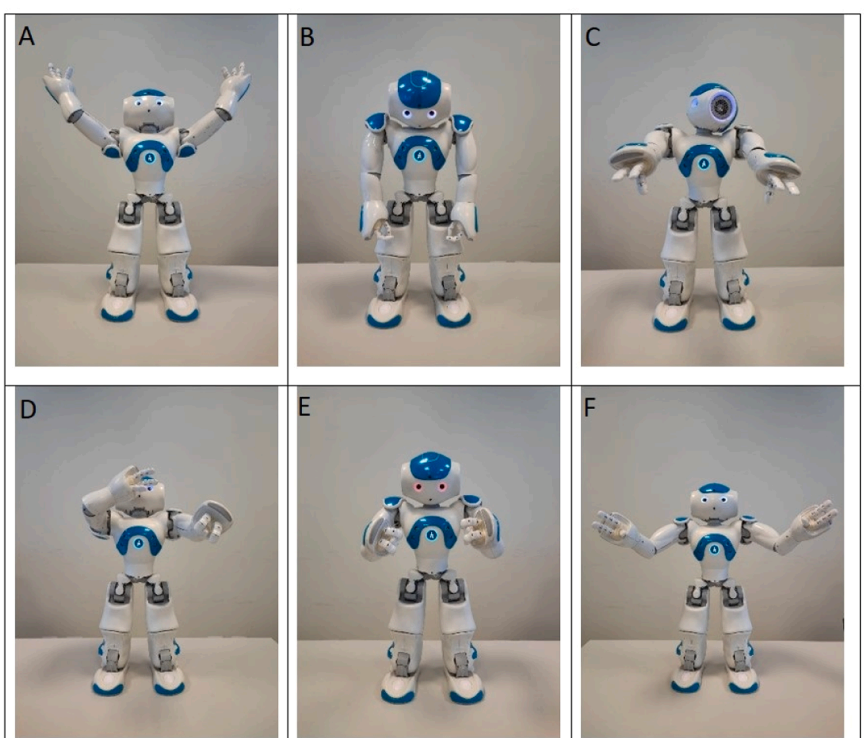

Fig. 1. Six robot emotional poses (*Legend:* A=Happiness, B=Sadness, C=Disgust, D=Fear, E = Anger, F=Surprise).

indicate clinically significant depression. The PHQ-9 is validated across diverse populations and widely used in both clinical practice and research.

2.3.6. Generalized Anxiety Disorder (GAD-7)

The GAD-7 (Spitzer et al., 2006) is a seven-item self-report scale assessing anxiety severity over the previous two weeks using a four-point frequency scale. Total scores range from 0 to 21, with scores of 10 or above indicating clinically relevant anxiety. It is a reliable and valid instrument, widely adopted across clinical and research contexts.

2.4. Statistical analysis

Data were analysed with SPSS version 31. Descriptive statistics, including frequencies, means, standard deviations, and bivariate correlations, were computed to explore the distribution and relationships between the study variables. For each emotion recognition modality (Ekman, video, and NAO), a total sum score of correct responses was calculated. Furthermore, stepwise multiple regression analyses were performed to predict the ability to recognize emotions across modalities. In all regression analyses, the stepwise method was used with a probability level for inclusion set at $p < .05$ and exclusion at $p > .10$. However, for the model predicting ability to recognize emotions in NAO, no variables were included using this criterion, as none showed significant correlations with the dependent variable. To explore possible trends in the data, the inclusion level was therefore adjusted to $p < .10$ for this model. Standardized coefficients (β) were used in stepwise linear regression to compare predictors. For logistic regression, unstandardized coefficients (B) and odds ratios (ORs) were reported, as these models are interpreted in terms of odds rather than standardized effects. In all models, the predictors included demographic variables (i.e., age, gender, and total years of dialysis) and psychological measures (alexithymia [TAS-20], anxiety [GAD-7], and depression [PHQ-9]). Multicollinearity was assessed using tolerance and variance inflation factor (VIF) values. All predictors showed acceptable levels (Tolerance >.60, VIF < 2.0), indicating that no multicollinearity issues were present. Logistic regression analyses were conducted to examine which variables predicted accurate recognition of each specific emotion across the three modalities. All predictors were included in the models, with the outcome variable coded as binary: correct responses as 1 and incorrect responses as 0. A significance level of.05 was applied in all tests.

3. Experimental procedure

The experiment was conducted in a hospital setting, in a quiet room with adequate lighting and ensured privacy. To guarantee the reliability of the procedure, a pre-study was conducted with four patients (2 males, 2 females; mean age = 49.5) who viewed the emotion videos and unanimously agreed on the emotions displayed.

Before the main session, each participant interacted with the NAO robot for approximately five minutes to reduce novelty effects. The room contained a computer screen, the NAO humanoid robot (H25, V4), and two researchers. To avoid introducing confounding variables, no sounds were used in the videos or robot expressions. Each experiment lasted approximately 10 min, divided into three sessions.

In the first session, participants completed the TAS-20, PHQ-9, and GAD-7 questionnaires (see Fig. 3).

During the second session, participants reviewed the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) before completing the emotion recognition test using images from Ekman and Friesen (1976). They then watched six Disney movie clips, each depicting one of the basic emotions through clear emotional body language without speech. The clips were presented in random order (see Table 1).

The happiness video showed the final scene of *Pinocchio*, where the puppet becomes a real boy and the characters celebrate. The sadness clip from *Lilo & Stitch* depicted a young girl excluded by her peers. The anger clip from *The Incredibles* featured a family dinner escalating into an argument. Disgust was represented by a scene from *The Emperor's New Groove*, in which the protagonist attempts resuscitation but feels disgusted. Fear was portrayed in a scene from *Monsters, Inc.*, where a monster scares a child at night. Surprise came from *The Road to Eldorado*, showing the protagonists arriving in the mysterious city (see Fig. 4).

Later in the second session, participants observed NAO expressing the six emotions in random order and were asked to identify the emotion after each expression. Afterwards, participants had the opportunity to

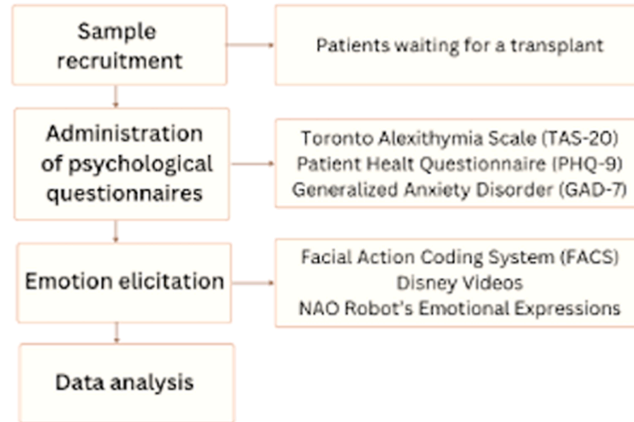

Fig. 2. Flowchart of the experimental procedure.

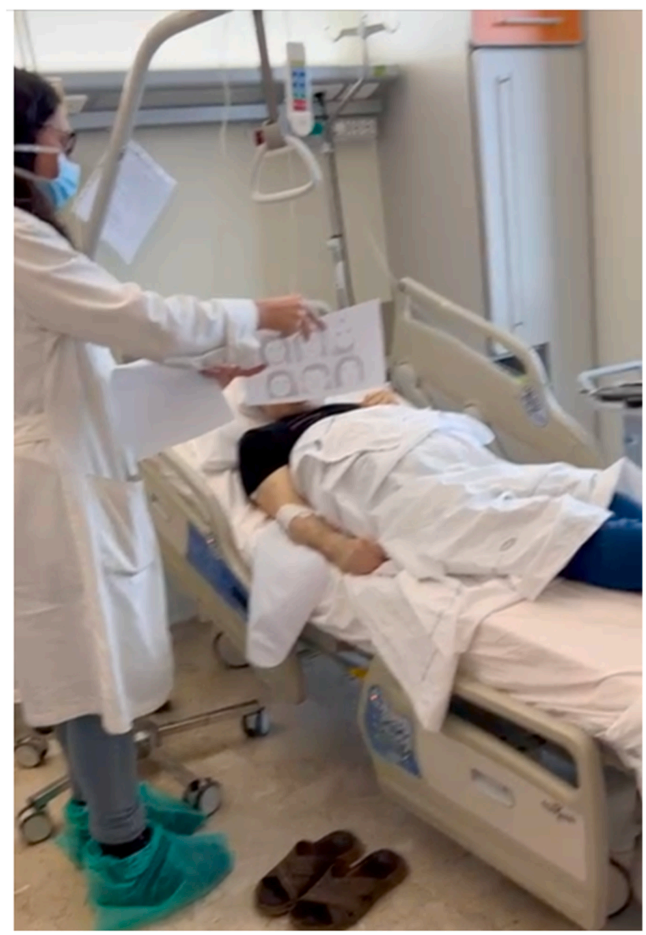

Fig. 3. Administration of the Ekman facial emotion recognition test by a psychologist.

Table 1
The figure illustrates in detail the emotion shown, the type of video used, and its duration.

EMOTION	VIDEO TITLE	MINUTES
Happiness	Pinocchio	00:27
Sadness	Lilo and Stitch	00:36
Disgust	The Emperor's New Groove	00:25
Fear	Monsters & Co.	00:45
Anger	The Incredibles	00:37
Surprise	The road to Eldorado	00:50

interact freely with NAO and ask questions.

The third session served as a debriefing phase, allowing participants to reflect on their experience and understand the study's purpose.

4. Results

4.1. Descriptives

The sample consisted of 60 adults, of whom 38 were men (63.3 %) and 22 were women (36.7 %). The age range was 20–80 years (M = 53.95, SD = 12.02). Education levels were distributed as follows: high school diploma (43.3 %), middle school (38.3 %), elementary school (10 %), and university degree (8.3 %). The duration of dialysis was positively skewed (skewness = 1.44, kurtosis = 1.98), ranging from 0 to 15 years (M = 3.30, SD = 3.34), and the median duration of dialysis treatment was 2.00 years (IQR = 3). None of the participants reported any prior experience with robots (0 %).

The mean TAS-20 score was 43.70 (SD = 12.08), with 15 participants (25.2 %) scoring above the clinical cutoff of 52, indicative of elevated alexithymia. The average PHQ-9 score was 4.58 (SD = 4.13), with the majority of participants (61.6 %) reporting symptom levels consistent with minimal depression, followed by 31.7 % with mild, 1.7 % with moderate, and 5.0 % with moderately severe depressive symptoms. The mean GAD-7 score was 4.43 (SD = 4.12), corresponding to minimal anxiety in 63.3 % of the sample, mild anxiety in 25.0 %, moderate anxiety in 5.0 %, and severe anxiety in 6.7 %.

Participants achieved the highest mean number of correct responses on the video-based task (M = 4.15, SD = 1.31), followed by the Ekman facial expression test (M = 3.92, SD = 1.49), and the NAO robot expressions task (M = 3.67, SD = 1.47). In the video-based task, the emotion "scared" was the most accurately identified, with 93 % of participants responding correctly, while "sad" was the least accurately identified, with only 35 % correct responses. In the Ekman test, "happy" was the most accurately recognized emotion (90 %), whereas "scared" had the lowest recognition rate (34 %). For the NAO robot expressions, "sad" was the most accurately identified emotion (90 %), while "disgust" had the lowest recognition rate, with only 33 % of participants identifying it correctly. See Table 2 for a complete overview of emotion recognition accuracy across modalities.

Correlation analyses indicated that the ability to recognize emotions in the Ekman test was associated with level of education (r = .27, p = .04) and GAD-7 scores (r = .26, p = .047). Furthermore, the ability to recognize emotions in videos was associated with age (r = -.41, p = .001), level of education (r = .38, p = .004), TAS scores (r = -.32, p = .014), and the ability to recognize emotions in the Ekman test (r = .26, p = .046). The ability to recognize emotions in NAO only correlated with the ability to recognize emotions in the videos (r = .31, p = .017; see Table 3 for the correlation matrix).

4.2. Predicting the ability to guess emotions across the modalities

A total of three stepwise multiple regression analyses was conducted to identify predictors across all modalities. A model summary including all the excluded variables, for each modality, are presented in the supplementary materials (Table S1 – Table S3).

The stepwise regression analysis showed that only education level (β =.26, p = .037) and anxiety level (GAD; β =.26, p = .043) were significant predictors of the recognition performance on the Ekman test. In the first step, education level was included in the model, explaining 7.1 % of the variance (R^2 =.071, F (1,58) = 4.42, p = .040). In the second step, anxiety levels were included in the model, resulting in additional 6.5 % (ΔR^2 =.065), being accounted for in the model (R^2 =.136, F (2,57) = 4.48, p = .016) (See Fig. 5).

In the stepwise regression analyses predicting recognition performance on videos, age entered the model and was a significant predictor, explaining approximately 17 % of the variance (R^2 =.169, F(1,58) = 11.80, p = .001). In the second step, alexithymia symptoms were included, and the total variation of the model was increased (ΔR^2 =.134), resulting in the final model explaining 30 % of the variance (R^2 =.303, F(2,57) = 12.41, p < .001; See Fig. 6). That is, older participants and participants with higher levels of alexithymia had a lower ability to recognize emotions in the videos.

When predicting recognition performance in NAO, age, alexithymia symptoms (TAS-20), years on dialysis, and education were included in the final models (across five steps; See Fig. 7 for the cumulative explained variance across the steps in the stepwise regression). The final model was significant, (F (5, 54) = 3.90, p = .004), and the included variables explained 27 % of the variance in the model (R^2 =.26.5). The

Fig. 4. Visual examples of the emotional video stimuli (*Legend:* A=Happiness, B=Sadness, C=Disgust, D=Fear, E = Anger, F=Surprise).

Table 2
Proportion of correct responses for each emotion across the three emotion recognition modalities.

Emotions	Ekman				VIDEO				NAO			
	Acc	%	Inacc	%	Acc	%	Inacc	%	Acc	%	Inacc	%
Anger	31	51.7	29	48.3	49	81.7	11	18.3	34	56.7	26	43.3
Fear	20	33.3	40	66.7	56	93.3	4	6.7	33	55.0	27	45.0
Disgust	49	81.7	11	18.3	31	51.7	29	48.3	20	33.3	40	66.7
Surprise	35	58.3	25	41.7	41	68.3	19	31.7	39	65.0	21	35.0
Happiness	54	90.0	6	10.0	50	83.3	10	16.7	41	68.3	19	31.7
Sadness	48	80.0	12	20.0	21	35.0	39	65.0	54	90.0	6	10.0

Note: Acc = accurate, Inacc = inaccurate

Table 3
Pearson correlations among demographic, psychological, and performance variables.

		M	*SD*	1	2	3	4	5	6	7	8	9	10	11
1	Age	53.95	12.02	–										
2	Gender	1.37	0.49	-.25	–									
3	Education	2.50	0.79	-.25	.13	–								
4	Dialysis	3.30	3.34	.20	**-.32***	**-.31***	–							
5	Transplant	1.72	0.49	-.11	-.13	.07	-.03	–						
6	TAS-20	43.70	12.08	-.12	.14	**-.28***	.05	-.06	–					
7	GAD-7	4.43	4.21	-.08	**.36****	.01	-.12	**-.26***	**.51****	–				
8	PHQ-9	4.58	4.13	.12	**.26***	-.15	.11	-.22	**.34****	**.71****	–			
9	EKMAN	3.92	1.49	.02	.18	**.27***	-.25	-.17	.04	**.26***	.02	–		
10	VIDEO	4.15	1.31	**-.41****	.21	**.37****	-.19	-.01	**-.32***	-.03	.01	**.26***	–	
11	NAO	3.67	1.47	-.25	-.11	.25	.17	-.18	-.20	.03	.08	.23	**.31***	

Note: $p < .01$ (**); $p < .05$ (*)

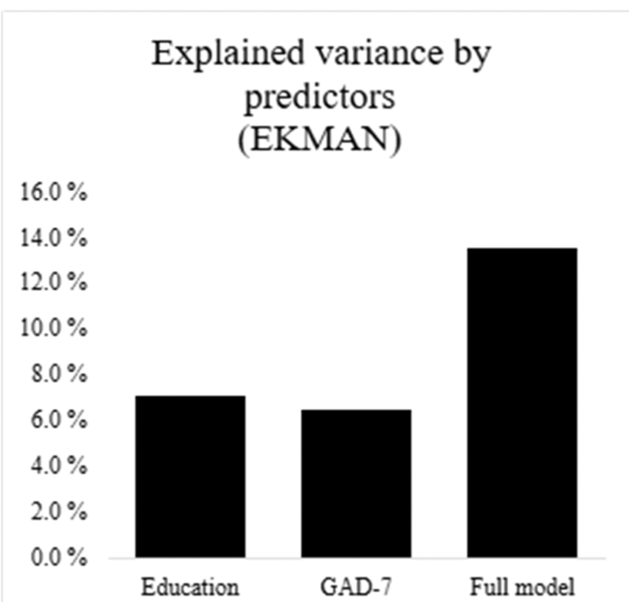

Fig. 5. Explained variance (R^2) in the stepwise regression model predicting Ekman.

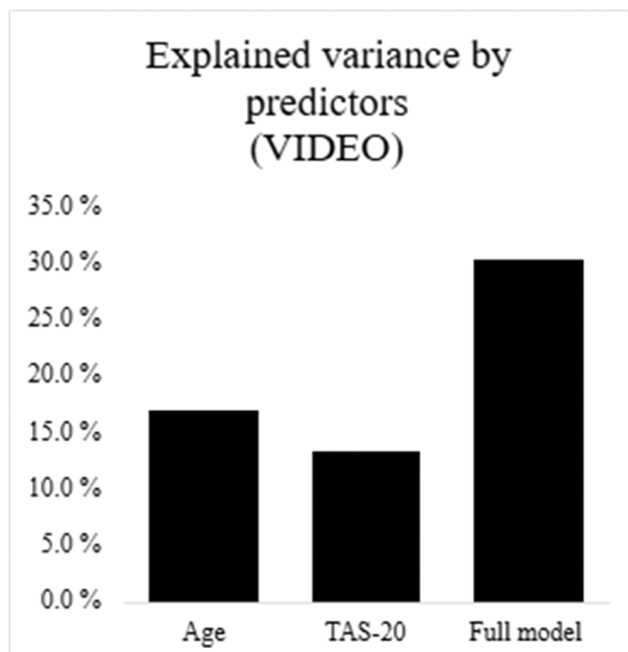

Fig. 6. Explained variance (R^2) in the stepwise regression model predicting emotions in videos.

final model indicated that age had a significant negative effect ($\beta = -.30$, $p = .020$), and years on dialysis a significant positive effect ($\beta = .31$, $p = .017$). Alexithymia ($\beta = -.20$, p = .109), transplantation ($\beta = -.23$, $p = .056$) and education ($\beta = .23$, $p = .090$) showed marginal associations, were not significant predictors in the model.

Table 4 illustrates participants' ability to recognize specific emotions across the different modalities. The following paragraphs highlight the significant predictors identified in the logistic regression analyses.

In the Ekman test, happiness recognition was predicted by TAS (OR = 0.84, $p = .028$), GAD (OR = 5.27, $p = .022$) and having received a kidney transplant (OR = 54.33, $p = .046$). Fear recognition was significantly associated with GAD (OR = 1.49, $p = .019$) and PHQ (OR = 0.61, $p = .005$). Surprise recognition was predicted by PHQ scores (OR = 0.69, $p = .040$). For the emotion sadness, anger and disgust, no significant associations were observed between the mental health outcomes and ability to recognize the emotions. However, older age predicted better recognition of sadness (OR = 1.11, $p = .045$), and years in dialysis were associated with lower odds of sadness recognition (OR = 0.68, $p = .014$). In the video tasks, PHQ scores were significantly associated with recognition of sadness (OR =1.37, $p = .017$). TAS scores

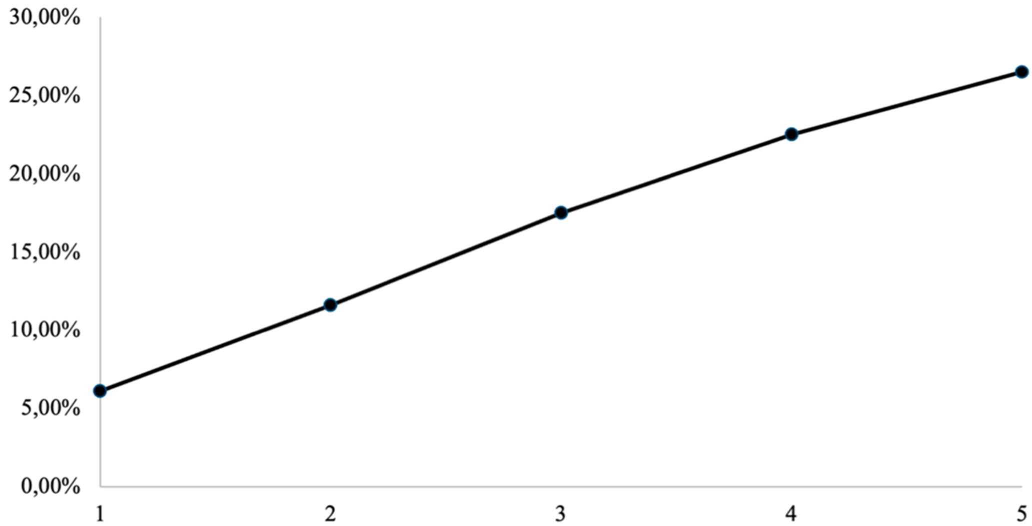

Fig. 7. Cumulative explained variance (R^2) across steps in the exploratory stepwise regression model for the NAO modality.

significantly predicted the recognition of disgust (OR = 0.94, $p = .028$). No other mental health outcomes were significantly associated with the participants ability to recognize the emotions in the video tasks. However, age was negatively associated with recognition of sadness (OR = 0.92, $p = .005$) and anger (OR = 0.90, $p = .018$), and years in dialysis were associated with lower odds of sadness recognition (OR = 0.69, $p = .041$).

When guessing the emotions in the NAO robot, only alexithymia (TAS) was negatively associated with the ability to recognize the emotion fear (OR = 0.94, $p = .046$). Furthermore, age was negatively associated with the recognition of the emotion sadness (OR = 0.86, $p = .019$) and surprise (OR = 0.94, $p = .034$).

5. Discussion

The present study explored the complex interplay between alexithymia, depression, anxiety, and emotion recognition in patients with chronic kidney disease (CKD) undergoing dialysis and awaiting renal transplantation. These findings should be regarded as preliminary and exploratory, and interpreted with caution in light of the study design and the absence of a healthy control group.

The pattern of associations observed in this study suggests that emotional difficulties such as anxiety, depression, and alexithymia tend to co-occur and may negatively influence socio-emotional functioning among patients with chronic kidney disease. In particular, emotion-recognition performance appeared to be more vulnerable in ecologically richer and visually complex contexts, such as video-based tasks, where greater integration of perceptual, cognitive, and affective processes is required. This finding is consistent with previous evidence indicating that chronic illness and psychological distress may affect higher-order socio-emotional abilities. Consistent with this interpretation, higher alexithymia and anxiety scores were associated with poorer performance in video-based tasks, whereas gender differences were more closely related to psychological symptom severity.

A notable finding of this study is the lower incidence of alexithymia, depression, and anxiety compared to typical rates reported in populations with chronic illnesses or awaiting organ transplantation (Ramya et al., 2024; Sharma et al., 2022). Although the present sample showed relatively low mean levels of anxiety and depression compared to previous reports in dialysis populations, this finding should be interpreted with caution. The hypothesis of "psychological resilience" may represent one possible explanation, as patients awaiting transplantation often develop adaptive coping strategies and may benefit from structured psychological support. However, it is equally plausible that the low scores reflect underreporting symptoms, possibly due to patients' tendency to minimize distress to maintain eligibility for the transplant waiting list or because of social desirability bias. In addition, a selection of bias cannot be ruled out, as individuals admitted to the transplant list are typically screened for psychological stability and adherence to medical treatment.

Therefore, these findings should be viewed as exploratory indications rather than conclusive evidence of resilience. Future research should integrate indirect and observational measures to verify the correspondence between self-reported and actual psychological status and to mitigate potential bias effects.

Taken together, these results suggest that anxiety may play a complex and nuanced role in socio-emotional processing. This finding may be interpreted in multiple ways. On the one hand, moderate levels of anxiety may increase vigilance toward social cues, thereby improving the ability to decode emotions in structured, prototypical formats such as Ekman faces (Muñoz Ladrón de Guevara et al., 2021). Conversely, high anxiety levels are often linked to emotional processing biases and impairments, particularly in recognizing negative emotions (Barbieri et al., 2022). In our sample, the subclinical anxiety symptoms may explain the positive association, suggesting that mild anxiety facilitates rather than impairs emotion recognition in standardized contexts.

Alexithymia scores significantly predicted poorer performance in recognizing emotions in both video-based tasks and interactions with the NAO robot. This aligns with literature characterizing alexithymia as a difficulty in identifying and describing one's own and others' emotional states (Farhoumandi et al., 2021; van Dijl et al., 2024). The reduced accuracy in recognizing dynamic and less conventional stimuli, such as expressive videos and robotic movements, supports the hypothesis that alexithymia may impair not only internal emotional awareness but also the interpretation of external emotional cues, particularly in complex and non-prototypical formats.

From a neurobiological perspective, alexithymia has been linked to dysfunction within fronto-limbic and salience-network circuits. Recent neuroimaging evidence shows reduced connectivity between the anterior cingulate cortex and insula—regions central to interoceptive and emotional awareness—in individuals with higher alexithymia scores (Motomura et al., 2023). Additional findings indicate diminished anterior insula activity associated with interoceptive deficits in alexithymic individuals (Shen et al., 2025). These alterations may help explain the reduced emotion-recognition performance observed in participants with higher alexithymia levels.

Furthermore, age emerged as a significant predictor, with younger participants outperforming older ones in emotion recognition tasks

Table 4
Logistic regression predicting recognition of specific emotions across the modalities.

		Happiness			Sadness			Disgust			Fear			Anger			Surprise		
		B	OR	*p*	B	OR	*p*	B	OR	*p*	B	OR	*p*	B	OR	*p*	B	OR	*p*
Ekman	TAS	-0.18	0.84	**.028**	0.00	1.00	.919	-0.05	0.95	.183	0.00	1.00	.952	0.01	1.01	.837	0.00	1.00	.998
	GAD	1.66	5.27	**.022**	0.38	1.46	.225	0.37	1.44	.083	0.40	1.49	**.019**	-0.07	0.94	.569	0.33	1.39	.064
	PHQ	-0.40	0.67	.104	0.05	1.05	.721	-0.34	0.71	.062	-0.50	0.61	**.005**	0.12	1.13	.277	-0.37	0.69	**.040**
	Age	0.19	1.21	**.041**	0.10	1.11	**.045**	0.03	1.03	.419	0.02	1.02	.465	0.03	1.03	.308	-0.04	0.96	.112
	Gender	0.03	1.03	.983	0.70	2.02	.523	2.57	13.00	.053	0.74	2.09	.322	1.54	4.64	**.030**	-1.75	0.17	**.022**
	Years in dialysis	-0.19	0.82	.356	-0.38	0.68	**.014**	0.13	1.14	.383	0.03	1.03	.774	-0.02	0.99	.878	-0.13	0.88	.203
	Kidney transplant	4.00	54.33	**.046**	0.98	2.68	.349	-1.16	0.31	.330	-0.81	0.45	.199	-0.85	0.43	.201	-0.26	0.77	.689
Video	TAS	0.02	1.02	.689	-0.07	0.93	.112	-0.07	0.94	**.028**	-0.04	0.96	.529	-0.02	0.98	.559	-0.06	0.94	.055
	GAD	0.04	1.04	.827	-0.22	0.80	.116	0.12	1.13	.371	-0.52	0.59	.170	0.03	1.03	.833	-0.10	0.91	.432
	PHQ	-0.17	0.85	.248	0.32	1.37	**.017**	0.16	1.17	.252	0.29	1.33	.352	-0.03	0.97	.799	0.17	1.18	.201
	Age	-0.02	0.98	.549	-0.09	0.92	**.005**	-0.05	0.95	.057	-0.20	0.82	.160	-0.11	0.90	**.018**	-0.05	0.95	.093
	Gender	1.75	5.75	.098	-0.35	0.70	.661	-0.63	0.53	.366	n/a[a]	n/a[a]	.998	0.55	1.74	.569	-0.09	0.91	.902
	Years in dialysis	0.35	1.42	.068	-0.37	0.69	**.041**	0.13	1.13	.207	-0.56	0.57	.065	-0.06	0.95	.614	-0.12	0.88	.207
	Kidney transplant	0.16	1.18	.830	0.21	1.23	.782	-0.76	0.47	.280	-22.07	2.60	.997	-0.35	0.70	.686	0.42	1.52	.517
NAO	TAS	-0.04	0.96	.150	-0.02	0.98	.625	-0.05	0.95	.132	-0.06	0.94	**.046**	-0.02	0.98	.495	-0.03	0.97	.301
	GAD	0.06	1.06	.659	-0.22	0.80	.357	0.08	1.08	.532	-0.04	0.96	.746	0.01	1.01	.951	0.04	1.04	.766
	PHQ	0.01	1.01	.920	0.19	1.20	.439	-0.01	0.99	.953	0.26	1.30	.095	0.10	1.10	.361	0.01	1.01	.934
	Age	-0.04	0.97	.205	-0.15	0.86	**.019**	-0.02	0.98	.394	-0.03	0.97	.215	-0.04	0.96	.136	-0.06	0.94	**.034**
	Gender	-0.87	0.42	.228	0.67	1.95	.644	-1.23	0.29	.110	-0.44	0.64	.523	-0.26	0.77	.699	-0.65	0.52	.349
	Years in dialysis	0.25	1.28	.073	0.02	1.02	.920	-0.02	0.99	.881	0.18	1.20	.106	-0.14	0.87	.169	0.12	1.13	.250
	Kidney transplant	0.19	1.21	.760	-0.08	0.93	.944	-0.91	0.40	.141	-0.932	0.394	.188	-0.96	0.38	.158	-0.46	0.63	.476

Note: TAS = Toronto Alexithymia Scale, GAD = Generalized Anxiety Disorder scale, PHQ = Patient Health Questionnaire. a All females (100 %) and 89.5 % of males correctly identified this emotion. Due to this performance and the lack of variance in the female group, logistic regression could not reliably estimate the effect of gender.

involving videos and the NAO robot. This finding is consistent with existing research highlighting age-related declines in social cognition and emotional processing abilities (Balter et al., 2021; Tsentidou et al., 2022). The positive association between dialysis duration and NAO performance should be interpreted cautiously, as it may reflect unmeasured adaptive factors or chance variability rather than a true functional advantage.

Interestingly, fear and disgust were often poorly recognized during interactions with the humanoid robot. The low accuracy observed for recognizing disgust and fear may partly reflect the expressive limitations of the NAO robotic platform rather than solely the patients' psychological characteristics. Recent studies have shown that negative or complex emotions are generally more difficult to decode when expressed by humanoid robots due to limited facial mobility and less natural body signaling. For instance, Valagkouti et al. (2022) reported that recognition accuracy for emotions displayed by NAO varies across categories, with lower performance for disgust and surprise. Similarly, Gao et al. (2024) found—through behavioral and eye-tracking data—that human observers tend to confuse negative emotions expressed through robotic body movements. Consistent with these findings, it seems reasonable to interpret the reduced recognition rates as the outcome of combined technological, methodological, and individual factors (Spezialetti et al., 2020; De Pasquale et al., 2017, 2014).

Another important consideration concerns the potential influence of clinical factors typical of the dialysis population, such as chronic fatigue, attentional fluctuations, and sleep–wake disturbances, which may affect overall cognitive performance and, consequently, emotion recognition accuracy.

Fatigue is one of the most commonly reported symptoms among dialysis patients, often related to anemia, metabolic imbalances, blood pressure variability, and the physiological stress of treatment. This condition can reduce available cognitive resources, limiting sustained attention, and perceptual discrimination processes that are essential for identifying emotions.

Similarly, attentional fluctuations due to intradialytic hypotension, sleep disturbances, or general discomfort may contribute to lower performance, particularly in more demanding or less familiar tasks, such as interpreting emotions expressed by a humanoid robot.

Although these factors were not directly assessed in the present study, their potential influence represents a methodological limitation. Future research should include objective measures of fatigue and attention to better clarify the extent to which these variables may mediate or moderate the relationship between psychological factors (anxiety, depression, alexithymia) and emotion recognition performance.

Chronic illness is frequently accompanied by emotional distress, altered self-perception, social withdrawal, lifestyle changes, and a profound sense of uncertainty or resignation. These psychosocial challenges negatively affect both quality of life and medical outcomes. Psychological symptoms—especially anxiety and depression—have been associated with poorer post-transplant prognoses (Uyar, 2022). Overall, these findings tentatively suggest the importance of integrating psychological, cognitive, and individual differences into assessments of socio-emotional competencies, with critical implications for targeted interventions in both clinical and rehabilitative settings.

Finally, the use of social robotics in the context of chronic disease has shown benefits in assisting people with physical recovery and rehabilitation needs (Eriksson et al., 2005; Kang et al., 2005), in neurological diseases for gait training (Hotz et al., 2024), as complementary tools for the treatment of chronic kidney disease (Chen et al., 2025), in cystic fibrosis (Russell et al., 2021), and with children with type 1 diabetes to convey good chronic disease management practices through play (Barata, 2020). All this evidence demonstrates their potential as tools for rehabilitation in the context of chronic disease.

6. Conclusion, limitations, and future work

This preliminary study provides exploratory insights into the relationships between alexithymia, anxiety, depression, and emotion recognition in patients with chronic kidney disease undergoing dialysis and awaiting transplantation. Although our sample did not show high scores on the variables examined, these psychological challenges could emerge over the long-term management of chronic disease and following organ transplantation. Identifying a possible alexithymia profile in dialysis patients during the pre-transplant period could enable ongoing monitoring throughout the transplant process and may be associated with patients' ability to manage and understand emotional difficulties and potential psychological symptoms that could relate to treatment adherence in the post-transplant phase (De Pasquale et al., 2016).

This study has some limitations. While the sample size was adequate for regression analyses and the design was cross-sectional, additional factors should be considered. First, the absence of a healthy control group limits inferences regarding whether the observed associations are disease-specific. Second, no correction for multiple comparisons was applied, which may affect the reliability of the regression findings. Third, potential collinearity among psychological variables (anxiety, depression, alexithymia) could inflate or obscure specific effects. Fourth, the use of self-report measures may not fully capture patients' emotional functioning. Another limitation of this study is the absence of direct cognitive measures (e.g. attention, processing speed, executive functions), which restricts the neuropsychological interpretation of the results. However, given the exploratory design and the clinical context of dialysis sessions, this choice aimed to minimize participant fatigue. Future studies should include cognitive assessments to verify whether some emotion recognition difficulties may partly reflect underlying cognitive constraints. A critical point that deserves attention is also the distinction between statistical significance and clinical relevance. Although several regression coefficients reached statistical significance, their magnitudes were small, suggesting that these associations, while theoretically meaningful, should be interpreted with caution.

Statistical significance indicates that an observed effect is unlikely to be due to chance, but it does not necessarily imply clinical importance. The modest size of the effects may reflect interindividual variability, the multifactorial nature of emotional processes, and the clinical heterogeneity typical of the dialysis population. Therefore, the conclusions of this study should be considered preliminary and primarily hypothesis-generating. The present findings highlight potential trends that warrant confirmation through longitudinal designs, larger samples, and the inclusion of neuropsychological and physiological measures.

Despite these limitations, the study provides an initial contribution to understanding how alexithymia, anxiety, and depression relate to emotion recognition in chronic kidney disease, highlighting potential implications for both clinical practice and technological applications. However, participants had no prior experience with humanoid robots, and their responses may partly reflect novelty or cognitive load effects; therefore, results should be interpreted with caution.

Future research should adopt longitudinal and multimodal approaches, integrating behavioral, cognitive, physiological, and neuroimaging measures to clarify how psychological factors shape emotion recognition over time. Examining how these abilities relate to interpersonal functioning, quality of life, and treatment adherence before and after transplantation would provide additional clinical value. Moreover, future studies should include an appropriate control group to strengthen the interpretability and validity of the findings.

Finally, identifying patient subgroups characterized by high alexithymia or other psychological vulnerabilities may support the development of targeted interventions aimed at improving socio-emotional functioning and psychosocial outcomes across the transplant pathway.

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CRediT authorship contribution statement

Concetta De Pasquale: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Maria Luisa Pistorio:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization. **Helene Høgsdal:** Methodology, Formal analysis, Data curation. **Carla Cirasa:** Methodology, Investigation, Formal analysis. **Daniela Conti:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Daniela Conti reports financial support from the University of Catania, Department of Humanities, through the PIACERI 2024–2026 Line 1 project BENTEC (A8722222554). She is employed at the same institution. Concetta De Pasquale reports financial support from the University of Catania, Department of General Surgery and Medical-Surgical Specialties, through the PIACERI 2024–2026 Line 1 project Evo MAF-Mof (5C722012155). She is employed at the same institution. All other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ajp.2026.104878.

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