

Patient-Reported Pre-Transplant Experiences and Psychological Outcomes after Kidney Transplantation: a Structural Equation Modeling Study

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ABSTRACT

Background: Kidney transplantation is the preferred treatment for end-stage kidney disease, but long-term success depends not only on graft outcomes, but also on psychological adaptation and treatment adherence. Evidence on the associations between retrospectively reported pre-transplant experiences and post-transplant psychosocial outcomes remains limited, particularly in Central Asia. This study examined the direct and indirect associations of waiting-related emotional burden, satisfaction with pre-transplant care, awareness, and psychological support with post-transplant anxiety, psychological well-being, and ease of treatment adherence among kidney transplant recipients in Kazakhstan.

Methods: A cross-sectional survey was conducted among 223 adult kidney transplant recipients in Kazakhstan. Latent-variable structural equation modeling was performed in Mplus 8.5 using WLSMV estimation for ordinal indicators. The model included waiting-related emotional burden, satisfaction with pre-transplant care, awareness, anxiety, and well-being as latent constructs.

Results: The model showed acceptable fit (RMSEA=0.068, CFI=0.975, TLI=0.971, SRMR=0.074). Waiting-related burden had the largest standardized association with anxiety ($\beta=0.482$, $p<0.001$) and was also associated with lower well-being ($\beta=-0.304$, $p=0.001$). Anxiety was associated with lower well-being ($\beta=-0.133$, $p=0.046$) and lower perceived ease of treatment adherence ($\beta=-0.306$, $p<0.001$). Waiting-related burden also showed significant indirect associations with lower well-being and lower perceived ease of adherence through anxiety. Pre-transplant care satisfaction was positively associated with awareness and perceived ease of adherence, but also with greater post-transplant anxiety. Awareness was positively associated with well-being, and pre-transplant care satisfaction showed a significant positive indirect association with well-being through awareness. Psychological support during waiting was not associated with anxiety.

Conclusion: Retrospectively reported pre-transplant experiences were associated with post-transplant psychosocial adjustment. Waiting-related burden showed the strongest adverse pattern of associations, whereas awareness was positively associated with well-being. These findings support further prospective evaluation of coordinated psychosocial support before and after transplantation.

Keywords: Kidney Transplantation; Anxiety; Quality of Life; Medication Adherence; Waiting Lists; Health Literacy; Patient-Centered Care.

Introduction

Kidney transplantation (KTx) is widely recognized as the preferred treatment for end-stage kidney disease compared with long-term dialysis. However, long-term transplant success depends not only on surgical and immunological outcomes, but also on patients' psychological adaptation and treatment adherence. Emotional distress, particularly anxiety, and difficulties in maintaining adherence to immunosuppressive regimens remain significant contributors to graft complications and reduced quality of life [1, 2]. Accordingly, successful transplantation should be understood not only in terms of physical recovery, but also in terms of mental well-being and patients' ability to manage complex long-term treatment demands [3].

The pre-transplant period, particularly time spent on the waiting list, can involve substantial psychological and functional burden. For many patients, this period functions as a prolonged stress exposure characterized by uncertainty about transplant timing, fear of clinical deterioration or death, progressive physical limitation, and reduced autonomy in daily life [4]. Prior studies have shown that psychological stress is highly prevalent among kidney transplant candidates, with longer waiting-list duration independently associated with greater stress severity [5]. Other work has identified fear of death, inner conflict, uncertainty, and loss of social roles and autonomy as central emotional stressors during this phase [6]. Importantly, longitudinal evidence suggests that patients with poorer emotional well-being before transplantation may follow declining rather than improving psychological trajectories during the first post-transplant years, suggesting that poorer emotional well-being before transplantation may remain relevant after transplantation [7]. Based on this reasoning, the following hypotheses were formulated:

H1: Greater waiting-related emotional burden will be positively associated with post-transplant anxiety.

H2: Greater waiting-related emotional burden will be negatively associated with psychological well-being.

At the same time, some pre-transplant experiences may represent potentially modifiable correlates of post-transplant adjustment. Satisfaction with pre-transplant care and awareness of the transplant process may be considered modifiable health-system factors that can potentially be improved through communication, counseling, education, and more responsive healthcare services. In Kazakhstan, transplantation services have expanded considerably over the past decade, with national programs in heart, kidney, and liver transplantation demonstrating increasing capacity and clinical outcomes [8-10]. Within such systems, patients' experiences of care may be associated with their trust in clinicians, understanding of the transplant process, and readiness to engage in long-term treatment. Evidence suggests that better patient-perceived care quality is associated with superior transplant outcomes, while qualitative studies highlight communication quality, clarity of information, and staff responsiveness as especially important dimensions of care from the patient perspective [11,12]. A better understanding of the transplant process may enhance patients' sense of control and coping capacity, whereas positive experiences with healthcare providers may strengthen engagement with treatment [1]. Accordingly, the following hypotheses were formulated:

H3: Greater satisfaction with pre-transplant care will be positively associated with higher procedural awareness.

H4: Higher procedural awareness will be positively associated with psychological well-being and may also be positively associated with greater perceived ease of adherence.

Psychological support may represent an additional protective factor across the transplantation process. Both professional support from the healthcare team and broader social

support from family or close others may help patients cope with uncertainty, regulate distress, and sustain treatment routines. Previous evidence has shown that social support is closely linked to post-transplant medication adherence, identifying it as one of the strongest psychosocial correlates of adherence among kidney transplant recipients [7,13]. These findings suggest that supportive interpersonal and clinical environments may buffer the emotional burden of transplantation and facilitate adaptation after surgery.

Health- and treatment-related anxiety may represent an important psychological correlate within the associations between retrospectively reported pre-transplant experiences and post-transplant outcomes. In the hypothesized model, anxiety was examined as an intermediate statistical correlate within the associations of waiting-related burden with well-being and perceived ease of treatment adherence. Given the cross-sectional design, this pathway was considered associative rather than causal or temporally established. Prior research has suggested that anxiety experienced during the pre-transplant period may persist after surgery and may be closely intertwined with adherence to immunosuppressive therapy [14]. In addition, internalizing symptoms, including anxiety, have been shown to mediate the relationship between perceived barriers and medication adherence in transplant recipients [15]. Based on this framework, the following hypotheses were formulated:

H5: Higher post-transplant anxiety will be negatively associated with psychological well-being and perceived ease of adherence.

H6: Significant indirect associations will be observed between pre-transplant experiences and post-transplant outcomes through anxiety and awareness. Specifically, waiting-related emotional burden will show indirect associations with psychological well-being and perceived ease of adherence through anxiety, while pre-transplant care satisfaction will show an indirect association with psychological well-being through awareness.

Despite growing recognition of psychosocial factors in transplantation, important gaps remain in the literature. Most existing studies have examined these associations in high-resource settings, and relatively little is known about how pre-transplant experiences are related to post-transplant outcomes in countries such as Kazakhstan, where access to care, service navigation, and regional disparities may differ. Moreover, few studies have tested these relationships simultaneously using integrated latent-variable models that can estimate direct and indirect associations simultaneously. This gap is particularly relevant in Central Asia. Recent studies from Kazakhstan found that post-transplant anxiety and difficulties in accessing care were negatively associated with well-being among kidney transplant recipients [16,17]. However, these studies focused on post-transplant correlates and did not examine retrospectively reported pre-transplant experiences or their indirect associations with later outcomes.

Therefore, the present study aimed to comprehensively assess pre-transplant experiences among 223 adult kidney transplant recipients in Kazakhstan, including waiting-related emotional burden, awareness, satisfaction with care, and psychological support, and to examine their direct and indirect associations with post-transplant anxiety, well-being, and perceived ease of adherence. Using a latent-variable structural equation modeling approach, we tested whether waiting-related burden was associated with greater anxiety and poorer well-being, whether satisfaction with pre-transplant care was associated with greater awareness, and whether significant indirect associations through anxiety and awareness were present between pre-transplant experiences and post-transplant outcomes.

Methods

Participants and study population

This cross-sectional study was conducted among adult kidney transplant recipients in Kazakhstan. Data were collected from February to April 2025 using online and telephone-based surveys. The survey invitation was initially distributed to 962 kidney transplant recipients. The online survey link was shared through patient-support group chats, while additional potential participants were contacted by telephone.

A total of 236 individuals responded. Eligibility criteria were: (1) age ≥ 18 years; (2) kidney transplantation performed in Kazakhstan; and (3) ability to complete the questionnaire in Kazakh or Russian. Eleven respondents were excluded because they did not meet the transplantation criterion: 10 had undergone kidney transplantation abroad, and one had undergone a second kidney transplantation. Of the remaining 225 eligible respondents, two were excluded because of incomplete questionnaire responses. Consequently, 223 participants were included in the final descriptive and structural equation analyses.

Sociodemographic and basic clinical characteristics, including age, sex, residence, education, and kidney disease duration, were collected at the time of participation using a structured questionnaire and are presented in Table 1.

Participants had a mean age of 38.7 ± 10.4 years (range 18–64). For descriptive purposes, age was grouped into 18–39

years ($n = 118$; 52.9%) and 40–64 years ($n = 105$; 47.1%). The sample included 98 men (43.9%) and 125 women (56.1%). Regarding language of participation, 96 (43.0%) completed the questionnaire in Kazakh and 127 (57.0%) in Russian.

Kidney disease duration was <1 year (20.6%), 1–3 years (33.2%), 4–5 years (9.9%), or >5 years (36.3%). Residence was rural (14.8%), small town (13.0%), regional-level city (33.6%), or national-level city (38.6%). Most participants were married (60.5%) and had children (64.6%). Education levels were middle-school (4.9%), high-school (9.9%), vocational (26.0%), undergraduate (58.3%), and post-graduate (0.9%).

Measures

Pre-transplant experiences were assessed using several patient-reported indicators capturing waiting-related emotional burden, perceived quality of pre-transplant care, informational preparedness, and psychological support:

- Waiting-related emotional burden (WaitImpact indicators): Emotional distress during the waiting-list period was measured with WLStress, reflecting how often participants experienced stress/anxiety/depressive feelings while waiting (1 = never to 5 = always). The functional impact of waiting on everyday life was assessed with WLAffect, indicating the degree to which waiting limited daily activities (1 = not limited to 4 = very strongly limited).

- Psychological support during waiting (WPsyCare). Perceived access to psychological or emotional support while on the waiting list was assessed using a single ordinal item rated on a 3-point scale (1 = no support, 2 = sometimes, and 3 = regularly). Psychological support was specified as a predictor of anxiety only, reflecting the prespecified conceptual assumption that support received during the waiting period would be most proximally related to emotional distress, whereas any associations with well-being or perceived ease of adherence might operate indirectly through anxiety. Because psychological support was measured using a single item, additional direct pathways to these more distal outcomes were not included in order to preserve model parsimony and avoid overinterpretation of a limited measure.

- Awareness and informational preparedness (Awareness indicators): Self-reported knowledge about the transplantation process was measured in two domains: awareness of waiting-list procedures (AwaWL) and awareness of pre-transplant procedures (AwaPreKTx). Both items were rated from 1 = not informed at all to 5 = well informed.

- Satisfaction with pre-transplant care (PreCare indicators): Satisfaction with healthcare services during the waiting period was measured using SatHCSW (higher scores indicate greater satisfaction). In addition, three items assessed satisfaction with key aspects of pre-KTx care: healthcare service quality during the pre-transplant period (SatpKT1), quality of consultations before transplantation (SatpKT2), and availability of diagnostic tests (SatpKT3). All satisfaction indicators were coded such that higher ratings reflect higher satisfaction.

Post-transplant outcomes:

- Health- and treatment-related anxiety (Anxiety; ANX1–ANX7). Post-transplant anxiety was assessed using a previously validated 7-item kidney-transplant-specific measure developed for kidney transplant recipients in Kazakhstan [16]. The measure captures common post-transplant concerns, including infection risk under immunosuppression, worries about maintaining graft function, anxiety about unfavorable laboratory results, long-term health stability, financial burden of ongoing treatment, low mood or depressive feelings, and concerns about immunosuppressant side effects. Items were

Table 1 Study population (N=223)

Variable	n	%
Gender		
Male	98	43.9
Female	125	56.1
Age group		
18–39 y.o.	118	52.9
40–64 y.o.	105	47.1
Language		
Kazakh	96	43.0
Russian	127	57.0
Kidney disease duration		
< 1 year	46	20.6
1–3 years	74	33.2
4–5 years	22	9.9
> 5 years	81	36.3
Residence		
Rural	33	14.8
Small town	29	13.0
Regional-level city	75	33.6
National-level city	86	38.6
Occupation		
Student	19	8.5
Employed	82	36.8
Self-employed	26	11.7
Unemployed	18	8.1
Pensioner	9	4.0
On disability	69	30.9
Marital status		
Single	66	29.6
Married	135	60.5
Divorced	17	7.6
Widow	5	2.2
Children		
No	79	35.4
Yes	144	64.6
Educational level		
Middle-school	11	4.9
High-school	22	9.9
Vocational	58	26.0
Undergraduate	130	58.3
Post-graduate	2	0.9

rated on a 5-point frequency scale ranging from 1 = never to 5 = always, with higher scores indicating greater health- and treatment-related anxiety [1,16].

- Psychological well-being (WellBeing; WHO-5). Subjective well-being was measured using the WHO-5 Well-Being Index (5 positively worded items). Each item was rated from 0 (at no time) to 5 (all of the time). Raw scores (0-25) were summed and multiplied by 4 to produce a standardized 0-100 score, where higher values indicate better psychological well-being [18].

- Ease of treatment adherence (EasyToAd). Perceived adherence was captured with a single self-report item assessing how easy vs. difficult it is for participants to follow their post-transplant treatment regimen, explicitly including regular intake of immunosuppressive medication. Responses were recorded on a 5-point scale, anchored from 5 = "very easy to follow" to 1 = "I do not follow" (higher scores = easier adherence).

Statistical analysis

Descriptive analysis. Categorical variables were summarized using frequencies and percentages, whereas continuous variables were described using means and standard deviations (SD).

Structural equation modeling. The hypothesized model was estimated in Mplus version 8.5 using the weighted least squares mean- and variance-adjusted estimator (WLSMV), theta parameterization, and a probit link. This approach was selected because most indicators were measured on ordered categorical response scales. Waiting-list stress, the perceived effect of waiting on daily life, the pre-transplant care-satisfaction indicators, the seven anxiety indicators, the five WHO-5 indicators, and perceived ease of treatment adherence were specified as ordered categorical variables and modeled through underlying continuous response variables with category thresholds freely estimated. The two awareness indicators (AwaWL and AwaPreKTx) were specified as continuous indicators of the latent Awareness construct rather than as ordered categorical variables. Although both variables were measured using five response categories, they were modeled as continuous because they served as indicators of an underlying latent construct rather than as endogenous ordinal outcomes. The treatment of five-category indicators as continuous is an accepted approach in structural equation modeling when category distributions are reasonably balanced and the variables provide reasonable approximations of an underlying continuous construct. In the present study, both awareness indicators showed relatively balanced response distributions and demonstrated satisfactory psychometric properties (standardized factor loadings: 0.693 and 0.868; $\omega = 0.76$), supporting this specification. Because the initial estimation produced an Mplus warning indicating that multiple numerical solutions were possible, the final model was re-estimated using 100 random starting values (STARTS = 100). Multiple random-start runs reproduced the same optimum solution, with unchanged parameter estimates and model-fit indices, supporting the numerical stability of the final model.

The measurement component comprised five latent constructs. Waiting-list impact was indicated by waiting-related emotional distress and the perceived limitation of daily life. Pre-transplant care satisfaction was indicated by satisfaction with healthcare services during the waiting period (SatHCSW), healthcare service quality during the pre-transplant period (SatpKT1), satisfaction with pre-transplant medical consultations (SatpKT2), and satisfaction with the availability of diagnostic tests during the pre-transplant period (SatpKT3).

Health- and treatment-related anxiety was represented by seven items, psychological well-being by the five items of the WHO-5 Well-Being Index, and awareness by self-reported awareness of waiting-list and pre-transplant procedures. Perceived ease of treatment adherence was modeled as a single observed ordinal outcome rather than as a latent adherence construct.

Latent-variable scales were established using marker-variable identification, with the first loading of each latent construct fixed to 1.0 and the remaining loadings freely estimated. Waiting-list impact and awareness were each represented by two indicators. These constructs were retained as latent variables because their indicators captured conceptually distinct but related dimensions of the underlying construct. Their identification was supported by the marker-variable scaling approach and the broader structural specification. Nevertheless, because two-indicator factors provide limited information for independently evaluating measurement structure, their interpretation was based on theoretical coherence, standardized factor loadings, 95% confidence intervals, residual variances, and indicator-level explained variance and was treated cautiously.

The measurement component was evaluated before interpretation of the structural associations. Standardized factor loadings, 95% confidence intervals, indicator residual variances, and indicator-level R^2 values were examined. The estimated thresholds were also inspected to confirm that they increased monotonically across the ordered response categories. Internal consistency was evaluated using coefficient omega for multi-item constructs where available; reliability estimates for the two-indicator waiting-list impact and awareness constructs were interpreted cautiously because such estimates do not substitute for a more extensively measured latent construct.

Survey language was recorded for all participants, with approximately 43% completing the Kazakh-language version and 57% completing the Russian-language version. The primary structural equation model was estimated in the pooled sample. Formal multigroup measurement-invariance testing by survey language was not conducted because the language-specific subgroup sizes were limited for estimating ordinal models with freely estimated thresholds and because some constructs contained only two indicators. The pooled analysis therefore assumes broadly comparable measurement properties across the two language versions, although this assumption could not be formally verified in the present study.

The structural component specified anxiety as a function of waiting-list impact, pre-transplant care satisfaction, awareness, psychological support during the waiting period, age, and sex. Psychological well-being and perceived ease of treatment adherence were regressed on anxiety, waiting-list impact, pre-transplant care satisfaction, awareness, age, and sex. Awareness was regressed on pre-transplant care satisfaction, age, and sex. Waiting-list impact and pre-transplant care satisfaction were allowed to covary, and a residual covariance was specified between psychological well-being and perceived ease of treatment adherence. Thus, the structural model adjusted for age and sex. Time since transplantation and several other potentially relevant clinical covariates, including donor type, dialysis duration, rejection history, post-transplant complications, and immunosuppressive regimen, could not be included because they were not collected in a sufficiently complete and standardized form across all participants. The estimated associations should therefore not be interpreted as being independent of these clinical characteristics.

Indirect associations. Model-based indirect associations were estimated for the prespecified structural sequences linking waiting-list impact and pre-transplant care satisfaction with psychological well-being and perceived ease of treatment adherence. Because the study was cross-sectional and pre-transplant experiences were assessed retrospectively after transplantation, these estimates were interpreted as indirect statistical associations consistent with the specified model rather than as evidence of temporal or causal mediation.

Model evaluation. Overall model fit was assessed using the chi-square test, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA) with its 90% confidence interval, and standardized root mean square residual (SRMR). Structural coefficients and indirect associations were reported as STDYX-standardized estimates with 95% confidence intervals and two-sided p values. Statistical significance was defined as $p < .05$.

Missing data. The analyzed variables showed complete covariance coverage, with one missing-data pattern and coverage values of 1.00 for all variable pairs. Accordingly, the SEM was estimated using 223 complete observations for the variables included in the model.

Sample-size considerations

No formal a priori sample-size calculation was performed because the study aimed to recruit all reachable eligible adult kidney transplant recipients during the data-collection period. Closed-form sample-size formulas for WLSMV-based structural equation models with ordinal indicators are not straightforward; therefore, sample adequacy was evaluated pragmatically in relation to model complexity and estimation stability. The achieved sample of 223 participants was considered adequate for the prespecified, relatively parsimonious model, which included five latent constructs measured by 20 indicators, one observed perceived ease-of-adherence outcome, and a limited set of covariates. The final model converged normally, demonstrated acceptable-to-good fit, and produced statistically significant factor loadings for all indicators. Nevertheless, the sample may have provided limited power to detect smaller

structural associations or support more complex subgroup analyses.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Local Bioethics Commission of the “University Medical Center” Corporate Fund (Protocol No. 3, 14 July 2023). Informed consent was obtained from all participants prior to participation, and anonymity/confidentiality were maintained.

Results

Pre-transplant experience, awareness, and satisfaction

In the pre-transplant phase, emotional strain during the waiting-list period was common (Table 2). Over half of participants (52.9%; $n=118$) reported experiencing stress, anxiety, or depressive feelings always or often, whereas 11.2% ($n=25$) indicated never having these feelings. Awareness about the waiting-list process varied markedly: nearly one-third described themselves as uninformed (31.8%; $n=71$), while an equal proportion reported being good or very well informed (31.8%; $n=71$). By contrast, knowledge of pre-transplant procedures was higher overall, with 66.4% ($n=148$) reporting good or very good awareness.

Satisfaction with care was generally favorable across domains. During the waiting period, 66.0% ($n=147$) reported being satisfied or very satisfied with healthcare service quality. Ratings were higher in the pre-transplant period: 80.7% ($n=180$) were satisfied or very satisfied with healthcare service quality, 79.8% ($n=178$) with medical consultations, and 74.9% ($n=167$) with the availability of diagnostic tests.

Waiting for transplantation was reported to limit daily life (WLAffect) very strongly by 21.5% ($n=48$) and strongly by 22.9% ($n=51$); 38.1% ($n=85$) reported partial limitation and 17.5% ($n=39$) reported no limitation. Regarding psychological/emotional support during the waiting period (WPsyCare), 43.0% ($n=96$) reported receiving it regularly, 23.8% ($n=53$) sometimes, and 33.2% ($n=74$) reported not receiving such support.

Table 2 Pre-KTx experience, awareness and satisfaction (N=223)

Variable	Response, n (%)				
Stress, anxiety, depression on Waiting list (WLStress)	Always 86 (38.6)	Often 32 (14.3)	Sometimes 56 (25.1)	Rarely 24 (10.8)	Never 25 (11.2)
Awareness on Waiting list procedures (AwaWL)	Very good informed 34 (15.2)	Well informed 37 (16.6)	Somewhat informed 39 (17.5)	Poorly informed 42 (18.8)	Uninformed 71 (31.8)
Awareness on Pre-KTx procedures (AwaPreKTx)	Very good informed 90 (40.4)	Good informed 58 (26.0)	Somewhat informed 47 (21.1)	Poor informed 13 (5.8)	Uninformed 15 (6.7)
Satisfaction with healthcare service quality during the waiting KTx (SatHCSW)	Very Satisfied 63 (28.3)	Satisfied 84 (37.7)	Somewhat satisfied 41 (18.4)	Dissatisfied 20 (9.0)	Not satisfied at all 15 (6.7)
Satisfaction with healthcare service quality (pre-KTx period, SatpKT1)	Very Satisfied 89 (39.9)	Satisfied 91 (40.8)	Somewhat satisfied 28 (12.6)	Dissatisfied 10 (4.5)	Not satisfied at all 5 (2.2)
Satisfaction with medical consultations (pre-KTx period, SatpKT2)	Very Satisfied 110 (49.3)	Satisfied 68 (30.5)	Somewhat satisfied 27 (12.1)	Dissatisfied 14 (6.3)	Not satisfied at all 4 (1.8)
Satisfaction with availability of diagnostic tests (pre-KTx period, SatpKT3)	Very Satisfied 95 (42.6)	Satisfied 72 (32.3)	Somewhat satisfied 34 (15.2)	Dissatisfied 18 (8.1)	Not satisfied at all 4 (1.8)

Data are presented as n (%). KTx = kidney transplantation. For awareness and satisfaction items, categories are displayed from the most favorable to the least favorable response. For WLStress, categories are displayed from the highest to the lowest reported frequency of distress.

Table 3 Standardized factor loadings (STDYX)

Latent factor	Indicator	Loading	95% CI	p	R2
KTx waiting-related emotional burden (WaitImpact)	WLStress	0.739	0.600 – 0.879	<0.001	0.547
	WLAffect	0.649	0.525 – 0.774	<0.001	0.422
Satisfaction with pre-transplant healthcare (PreCare)	SatHCSW	0.777	0.723 – 0.831	<0.001	0.603
	SatpKT1	0.834	0.787 – 0.880	<0.001	0.695
	SatpKT2	0.970	0.942 – 0.999	<0.001	0.942
	SatpKT3	0.934	0.906 – 0.963	<0.001	0.873
Awareness	AwaWL	0.693	0.593 – 0.793	<0.001	0.481
	AwaPreKTx	0.868	0.777 – 0.960	<0.001	0.754
Treatment-related Anxiety (Anxiety)	ANX1	0.853	0.808 – 0.898	<0.001	0.727
	ANX2	0.871	0.829 – 0.914	<0.001	0.759
	ANX3	0.827	0.779 – 0.875	<0.001	0.684
	ANX4	0.912	0.877 – 0.946	<0.001	0.831
	ANX5	0.637	0.544 – 0.729	<0.001	0.406
	ANX6	0.725	0.651 – 0.799	<0.001	0.525
	ANX7	0.824	0.770 – 0.878	<0.001	0.679
Well-being (WellBeing)	WHO1	0.926	0.904 – 0.949	<0.001	0.858
	WHO2	0.887	0.857 – 0.916	<0.001	0.787
	WHO3	0.920	0.896 – 0.945	<0.001	0.847
	WHO4	0.854	0.817 – 0.890	<0.001	0.729
	WHO5	0.854	0.816 – 0.893	<0.001	0.729

Values are STDYX-standardized factor loadings. CI = confidence interval; KTx = kidney transplantation; R² = indicator-level explained variance; STDYX = standardization based on the variances of both the predictor and outcome. WaitImpact = waiting-list impact; WLStress = emotional distress during the waiting-list period; WLAffect = perceived effect of waiting on everyday life; PreCare = satisfaction with pre-transplant healthcare; SatHCSW = satisfaction with healthcare service quality during the waiting-list period; SatpKT1 = satisfaction with healthcare service quality during the pre-transplant period; SatpKT2 = satisfaction with pre-transplant medical consultations; SatpKT3 = satisfaction with the availability of pre-transplant diagnostic tests; AwaWL = self-rated awareness of waiting-list procedures; AwaPreKTx = self-rated awareness of pre-transplant procedures; Anxiety = health- and treatment-related anxiety; ANX1-ANX7 = individual anxiety-scale indicators; WellBeing = psychological well-being; WHO1-WHO5 = individual items of the WHO-5 Well-Being Index. Higher standardized loadings indicate stronger relationships between indicators and their respective latent constructs. All p values are two-sided.

After transplantation, participants most commonly reported that following the prescribed treatment regimen, including immunosuppressive therapy, was very easy (43.5%; n=97) or easy (33.6%; n=75), whereas 18.8% (n=42) perceived it as somewhat difficult. A small proportion reported that treatment adherence was difficult (3.1%; n=7) or indicated that they did not follow the prescribed regimen (0.9%; n=2). The mean post-transplant anxiety score was 3.65±1.0 on a 1-5 scale. The mean WHO-5 Well-Being Index score was 66.1±24.6 on a 0-100 scale.

Structural equation modeling

A latent variable SEM was estimated in Mplus 8.5 using WLSMV (theta parameterization; probit link) to account for the ordinal indicators (N=223). The model specified five latent constructs: WaitImpact (WLStress, WLAffect), PreCare (SatHCSW, SatpKT1-SatpKT3), Awareness (AwaWL, AwaPreKTx), Anxiety (ANX1-ANX7), and WellBeing (WHO1-WHO5). Structural paths were estimated from WaitImpact, PreCare, and Awareness to Anxiety, WellBeing, and perceived ease of treatment adherence (EasyToAd). Awareness was additionally regressed on pre-transplant care satisfaction, age, and sex. Age and sex were included as covariates in the outcome equations, and WPsyCare was included as a predictor of Anxiety.

The model converged normally and demonstrated acceptable fit, $\chi^2(230)=467.96$, $p<0.001$, CFI=0.975, TLI=0.971, RMSEA=0.068 (90% CI 0.059-0.077), and SRMR=0.074. To evaluate numerical stability, the model was re-estimated using 100 random starting values (STARTS = 100). Multiple random-

start runs reproduced the same optimum solution, and the model-fit indices and parameter estimates were unchanged, supporting the stability of the final solution.

All indicators loaded significantly on their intended latent constructs. Standardized loadings ranged from 0.649 to 0.739 for waiting-list impact, from 0.777 to 0.970 for pre-transplant care satisfaction, from 0.637 to 0.912 for anxiety, from 0.854 to 0.926 for psychological well-being, and from 0.693 to 0.868 for awareness. Model-based internal consistency was high for pre-transplant care satisfaction ($\omega=0.93$), anxiety ($\omega=0.93$), and psychological well-being ($\omega=0.95$). Omega was 0.65 for waiting-list impact and 0.76 for awareness; these estimates should be interpreted cautiously because each construct contained only two indicators.

In the structural equation model, waiting-related burden (WaitImpact) showed the largest standardized association with post-transplant anxiety (Anxiety) among the modeled predictors ($\beta=0.482$, $p<0.001$). Satisfaction with pre-transplant healthcare was also statistically associated with greater post-transplant anxiety ($\beta=0.298$, $p=0.006$). In contrast, transplant-related awareness (Awareness) was not associated with anxiety ($\beta=-0.019$, $p=0.845$). Psychological care during the waiting period (WPsyCare) and the covariates age (Age) and sex (Sex) were not associated with anxiety in this model (Table 4, Figure 1A). This finding should be regarded as an exploratory, model-based statistical association rather than evidence of an independent relationship between pre-transplant care satisfaction and anxiety. Residual confounding by clinical complexity, care intensity,

Table 4 Structural paths (standardized; STDYX)

Outcome	Predictor	β (STDYX)	95% CI	p
Anxiety	WaitImpact	0.482	0.291 – 0.672	<0.001
	PreCare	0.298	0.085 – 0.510	0.006
	Awareness	-0.019	-0.211 – 0.172	0.845
	WPsyCare	0.000	-0.147 – 0.146	0.997
	Age	0.029	-0.111 – 0.170	0.681
	Sex	0.003	-0.141 – 0.148	0.963
WellBeing	Anxiety	-0.133	-0.264 – -0.002	0.046
	WaitImpact	-0.304	-0.486 – -0.122	0.001
	PreCare	-0.004	-0.187 – 0.180	0.968
	Awareness	0.240	0.064 – 0.416	0.008
	Age	-0.023	-0.167 – 0.120	0.749
	Sex	0.021	-0.116 – 0.157	0.766
Awareness	PreCare	0.604	0.512 – 0.695	<0.001
	Age	-0.157	-0.309 – -0.004	0.044
	Sex	-0.061	-0.211 – 0.089	0.427
EasyToAd	Anxiety	-0.306	-0.455 – -0.156	<0.001
	WaitImpact	-0.099	-0.313 – 0.116	0.367
	PreCare	0.239	0.042 – 0.436	0.018
	Awareness	0.099	-0.080 – 0.278	0.279
	Age	-0.002	-0.154 – 0.151	0.983
	Sex	0.020	-0.129 – 0.168	0.794

Coefficients are STDYX-standardized structural estimates. β = standardized regression coefficient; CI = confidence interval; STDYX = standardization based on the variances of both the predictor and outcome. WaitImpact = waiting-list impact; PreCare = satisfaction with pre-transplant healthcare; Awareness = transplant-related procedural awareness; WPsyCare = perceived access to psychological or emotional support during the waiting-list period; Anxiety = post-transplant health- and treatment-related anxiety; WellBeing = psychological well-being; EasyToAd = perceived ease of adherence to the post-transplant treatment regimen. Age was entered as a continuous variable. Sex was coded 1 = male and 2 = female; therefore, a positive coefficient represents a higher expected outcome value for female participants, although sex-related coefficients should be interpreted cautiously when nonsignificant. Higher EasyToAd scores indicate greater perceived ease of adherence. All p values are two-sided; $p < .05$ was considered statistically significant.

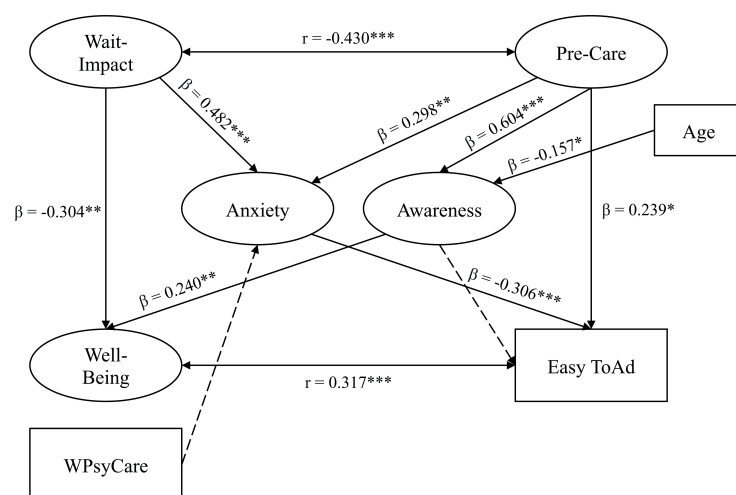
monitoring frequency, or other unmeasured factors cannot be excluded.

In the final structural model, greater post-transplant anxiety was associated with lower well-being ($\beta = -0.133$, $p = 0.046$), and greater waiting-related burden was directly associated with lower well-being ($\beta = -0.304$, $p = 0.001$). Greater transplant-related awareness was associated with higher well-being ($\beta = 0.240$, $p = 0.008$), whereas satisfaction with pre-transplant healthcare was not directly associated with well-being ($\beta = -0.004$, $p = 0.968$; Table 4; Figure 1A).

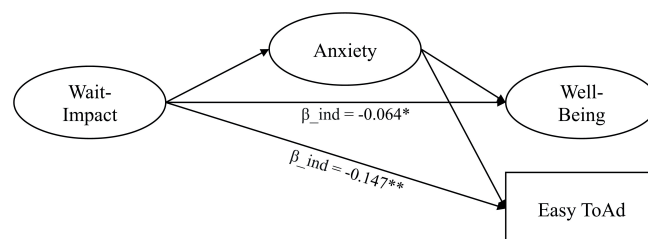
For EasyToAd, greater post-transplant anxiety was associated with lower perceived ease of adherence ($\beta = -0.306$, $p < 0.001$). In contrast, greater satisfaction with pre-transplant healthcare was associated with greater perceived ease of adherence ($\beta = 0.239$, $p = 0.018$). The direct associations of waiting-related burden and transplant-related awareness with perceived ease of adherence were not statistically significant.

At the level of relations among predictors and residuals, waiting-related impact and satisfaction with pre-transplant healthcare were negatively correlated ($r = -0.430$, 95% CI [-0.571, -0.289], $p < 0.001$; Figure 1A). After accounting for the modeled pathways, WellBeing and EasyToAd retained a positive residual correlation ($r = 0.317$, 95% CI [0.192, 0.442], $p < 0.001$; Figure 1A).

A. Final SEM showing standardized direct paths and residual correlations (STDYX)



B. Indirect associations of waiting-list impact through anxiety



C. Indirect associations of pre-transplant care through awareness and anxiety

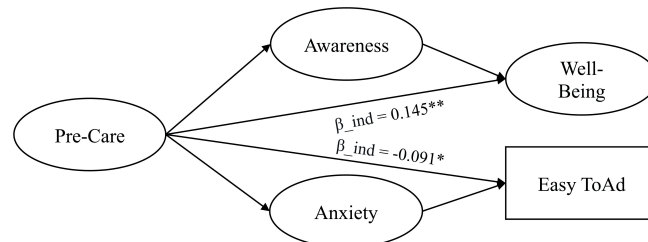


Figure 1 – Structural equation model of direct and indirect associations between retrospectively reported pre-transplant experiences and post-transplant psychosocial outcomes. Panel A: Final structural equation model showing statistically significant standardized direct paths and residual correlations. Panel B: Indirect associations of waiting-list impact with psychological well-being and perceived ease of treatment adherence through anxiety. Panel C: Indirect associations of pre-transplant care satisfaction with psychological well-being through awareness and with perceived ease of treatment adherence through anxiety.

Solid single-headed arrows indicate structural regression paths; double-headed arrows indicate correlations or residual correlations. Dashed arrows indicate nonsignificant paths retained in the model. Values are standardized coefficients (STDYX). β_{ind} denotes a standardized indirect association. Only selected statistically significant paths are labeled in Panel A. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Because the data were cross-sectional and pre-transplant experiences were assessed retrospectively, indirect associations should not be interpreted as evidence of temporal or causal mediation.

As illustrated in Figure 1B, waiting-related impact showed statistically significant indirect associations with both outcomes through anxiety. The indirect path waiting-related impact (WaitImpact) → post-transplant anxiety (Anxiety) → well-being (WellBeing) was negative ($\beta_{ind} = -0.064$, $SE = 0.031$, $p = 0.042$). Likewise, the indirect path waiting-related impact (WaitImpact) → post-transplant anxiety (Anxiety) → perceived ease of

Table 5

Standardized total, direct, and indirect effects (STDYX)

Predictor → Outcome	Total	Direct	Indirect (total)	Sign. specific indirect paths
WaitImpact → WellBeing	-0.369 (SE=0.079, p<0.001)	-0.304 (SE=0.093, p=0.001)	-0.064 (SE=0.031, p=0.042)	via Anxiety: -0.064 (SE=0.031, 95% CI [-0.126, -0.002], p=0.042)
WaitImpact → EasyToAd	-0.246 (SE=0.094, p=0.009)	-0.099 (SE=0.109, p=0.367)	-0.147 (SE=0.046, p=0.001)	via Anxiety: -0.147 (SE=0.046, 95% CI [-0.238, -0.057], p=0.001)
PreCare → WellBeing	0.103 (SE=0.072, p=0.152)	-0.004 (SE=0.094, p=0.968)	0.107 (SE=0.062, p=0.086)	via Awareness: 0.145 (SE=0.056, 95% CI [0.035, 0.254], p=0.009)
PreCare → EasyToAd	0.211 (SE=0.073, p=0.004)	0.239 (SE=0.101, p=0.018)	-0.028 (SE=0.068, p=0.683)	via Anxiety: -0.091 (SE=0.040, 95% CI [-0.169, -0.013], p=0.023)

Values are STDYX-standardized total, direct, and indirect associations. β_{ind} = standardized indirect association; CI = confidence interval; SE = standard error; SEM = structural equation modeling; STDYX = standardization based on the variances of both the predictor and outcome. WaitImpact = waiting-list impact; PreCare = satisfaction with pre-transplant healthcare; Anxiety = post-transplant health- and treatment-related anxiety; Awareness = transplant-related procedural awareness; WellBeing = psychological well-being; EasyToAd = perceived ease of adherence to the post-transplant treatment regimen. Higher EasyToAd scores indicate greater perceived ease of adherence. "Indirect (total)" represents the sum of all model-specified indirect associations between the predictor and outcome; therefore, it may differ from an individual specific indirect association shown in the final column. Only statistically significant specific indirect associations are displayed. All p values are two-sided; $p < .05$ was considered statistically significant. Because the data are cross-sectional and pre-transplant experiences were assessed retrospectively, direct, indirect, and total estimates represent model-based statistical associations and should not be interpreted as causal effects or evidence of temporal mediation.

adherence (EasyToAd) was negative ($\beta_{ind}=-0.147$, $SE=0.046$, $p=0.001$). In both cases, the total effect of waiting-related impact on the outcome was also negative (Table 5).

As shown in Figure 1C, satisfaction with pre-transplant healthcare demonstrated two distinct indirect patterns. Satisfaction with pre-transplant healthcare was strongly associated with transplant-related awareness (PreCare → Awareness; $\beta=0.604$, $p<0.001$; Figure 1A), and the specific indirect effect satisfaction with pre-transplant healthcare (PreCare) → transplant-related awareness (Awareness) → well-being (WellBeing) was positive and statistically significant ($\beta_{ind}=0.145$, $SE=0.056$, $p=0.009$; Figure 1C). In contrast, the specific indirect effect satisfaction with pre-transplant healthcare (PreCare) → post-transplant anxiety (Anxiety) → perceived ease of adherence (EasyToAd) was negative ($\beta_{ind}=-0.091$, $SE=0.040$, $p=0.023$; Figure 1C). Notably, this negative indirect pathway co-occurred with a positive direct association between satisfaction with pre-transplant healthcare and perceived ease of adherence ($\beta=0.239$, $SE=0.101$, $p=0.018$), yielding a positive total effect of satisfaction with pre-transplant healthcare on perceived ease of adherence ($\beta_{total}=0.211$, $SE=0.063$, $p=0.004$). These indirect

effects represent model-based statistical associations and should not be interpreted as establishing temporal sequencing or causal mediation.

Overall, the model accounted for 19.7% of the variance in post-transplant anxiety (Anxiety; $R^2=0.197$, $p=0.006$), 23.3% of the variance in well-being (WellBeing; $R^2=0.233$, $p<0.001$), and 39.4% of the variance in transplant-related awareness (Awareness; $R^2=0.394$, $p<0.001$). For perceived ease of adherence (EasyToAd), the explained variance was $R^2=0.232$ ($p<0.001$).

Discussion

This study examined associations between retrospectively reported pre-transplant experiences and current post-transplant psychosocial outcomes among kidney transplant recipients in Kazakhstan. Greater waiting-related burden was associated with greater post-transplant anxiety and lower well-being, whereas greater awareness was associated with better well-being. Satisfaction with pre-transplant care was associated with greater awareness and perceived ease of adherence, but also with greater post-transplant anxiety. These findings should be interpreted as cross-sectional associations rather than evidence of temporal or causal relationships.

Waiting-Related Burden and Anxiety

Greater waiting-related burden was directly associated with lower post-transplant well-being and indirectly associated with lower well-being and lower perceived ease of adherence through anxiety. Because waiting experiences were assessed retrospectively, the present study cannot establish persistence or temporal carryover. Nevertheless, the findings are consistent with evidence that uncertainty, fear of deterioration, and loss of autonomy contribute to psychological strain during the waiting period [19,20].

Recipients reporting greater waiting-related burden also reported higher post-transplant anxiety, which was associated with poorer well-being and lower perceived ease of adherence. This pattern is consistent with previous kidney-transplant research describing concerns about infection, medication adverse effects, laboratory results, graft rejection, and long-term graft survival [21,22]. Anxiety may be associated with greater cognitive and emotional load and with greater perceived difficulty managing long-term treatment demands. However, these processes were not directly measured, and reverse or bidirectional associations remain possible. Anxiety should therefore be interpreted as an intermediate statistical correlate rather than as a causal mechanism [1,2,14-16,23,24].

Awareness and Pre-Transplant Care

Awareness was positively associated with well-being, and pre-transplant care satisfaction showed a positive indirect association with well-being through awareness. Greater awareness may be related to increased predictability, perceived control, and reduced uncertainty regarding transplantation procedures and expectations. This interpretation is consistent with evidence that health communication interventions can improve recipients' ability to appraise health information and navigate care [25]. However, awareness was not directly associated with anxiety or perceived ease of adherence. Randomized and observational evidence similarly suggests that improved health literacy does not necessarily translate into better medication adherence [26].

Satisfaction with pre-transplant care showed a mixed pattern. Greater satisfaction was associated with greater perceived ease of adherence but also with greater post-

transplant anxiety. The positive association with perceived ease of adherence is consistent with evidence that communication quality, information availability, and staff responsiveness may support treatment engagement [11,12].

The positive association between satisfaction and anxiety should be considered exploratory and should not be interpreted as evidence that better care increased anxiety. Unmeasured clinical complexity, care intensity, monitoring frequency, or risk communication may have influenced both satisfaction and anxiety. Patients receiving more intensive care may have felt better supported while also being more concerned about rejection, complications, medication adverse effects, or graft survival. More engaged patients may also have reported both greater perceived ease of adherence and greater worry. Because these factors were not comprehensively measured, the explanation and direction of this association remain uncertain. Prospective studies are needed to distinguish among these possibilities [14,16].

Additional Model Findings

Waiting-related burden and pre-transplant care satisfaction were negatively correlated, indicating that recipients reporting more difficult waiting experiences also tended to report lower satisfaction with care. The direction of this association cannot be determined. The positive residual association between well-being and perceived ease of adherence suggests that these outcomes may share unmeasured correlates such as self-efficacy, social support, resilience, or coping resources [13,24]. Age and sex were not strongly associated with the main outcomes. The negative association between age and awareness may indicate that older recipients felt less informed, although this finding requires confirmation [25,26].

Clinical Implications

The findings support further evaluation of focused psychosocial assessment rather than broad service-level conclusions. Brief assessment of waiting-related distress, uncertainty, functional limitation, and transplant-related fears may help identify recipients who could benefit from closer follow-up, although prospective studies are needed to determine whether such screening improves outcomes [4-6,14,16,21].

Post-transplant anxiety was associated with lower well-being and greater perceived difficulty following treatment. Brief anxiety screening, clear communication about graft monitoring and medication adverse effects, and access to psychological support may therefore represent reasonable hypotheses for service improvement. The present study does not establish that these approaches would improve adherence or well-being [2,14,23,24].

Awareness was associated with well-being but not with perceived ease of adherence. Patient education may therefore be more useful when combined with emotional and behavioral support rather than delivered as information alone. Future studies should test whether integrated education, anxiety support, and referral procedures improve patient-reported and clinical outcomes [12,17,25,27-29].

Strengths and Limitations

This study examined retrospectively reported pre-transplant experiences and current post-transplant outcomes within one latent-variable framework. The SEM approach enabled simultaneous estimation of direct and indirect associations while accounting for measurement error. The study also contributes evidence from Kazakhstan, where psychosocial transplantation research remains limited.

Several limitations should be acknowledged. First, the cross-sectional design and retrospective assessment of pre-transplant experiences preclude conclusions about causality, temporal ordering, or prospective prediction. Current anxiety or well-being may have influenced recollections of waiting-list burden, awareness, psychological support, and satisfaction with care. The reported direct and indirect associations should therefore be interpreted as model-based statistical associations rather than temporal or causal relationships.

Second, selection bias is possible because participants were recruited through online support-group chats and telephone contact. This approach may have over-represented recipients who were more engaged with support networks, more connected to healthcare services, easier to contact, or more willing to participate. Recipients who were socially isolated, severely unwell, or living in areas with limited connectivity may have been under-represented. Because information on eligible nonparticipants was unavailable, the direction and magnitude of this bias could not be assessed.

Third, the study relied on patient-reported measures. Perceived ease of adherence was assessed using a single ordinal item and should not be interpreted as objective or multidimensional adherence. Psychological support was also measured using a single item that did not capture quality, intensity, timing, or duration. Future studies should use validated multidimensional adherence measures and objective indicators such as pharmacy refill data, immunosuppressant-level variability, or electronic monitoring.

Fourth, waiting-list impact and awareness were modeled as two-indicator latent variables, limiting independent evaluation of their measurement structure. The model also omitted potentially relevant psychological, clinical, and socioeconomic variables, including depression, illness perceptions, coping, resilience, self-efficacy, time since transplantation, donor type, dialysis duration, rejection, complications, immunosuppressive regimen, socioeconomic status, residence, and education. Residual confounding is therefore possible, particularly for the association between pre-transplant care satisfaction and anxiety. The moderate sample size may also have limited sensitivity to smaller associations and more complex subgroup analyses.

Finally, formal measurement invariance across the Kazakh- and Russian-language versions was not tested. The pooled model therefore assumes broadly comparable measurement properties across languages, but equivalence of factor loadings, thresholds, and item functioning cannot be confirmed. Larger studies should test configural, metric, and scalar or threshold invariance before comparing latent means or structural associations across language groups.

Future Research

Future studies should use prospective longitudinal designs beginning during the waiting-list period and continuing after transplantation. They should incorporate objective or multidimensional adherence measures, broader psychological constructs, and relevant clinical and socioeconomic covariates. Larger samples are needed to examine time since transplantation, complications, access to care, and language-specific measurement properties. Intervention studies should test whether combined education, anxiety support, and behavioral adherence strategies improve patient-reported and clinical outcomes. Future work could also examine how psychosocial factors interact with model-informed or artificial-intelligence-supported immunosuppressant dosing [30].

Overall, waiting-related burden, anxiety, awareness, and perceived pre-transplant care were interrelated correlates of

post-transplant adjustment. Prospective research is needed to determine their temporal direction and clinical significance.

Conclusion

In conclusion, retrospectively reported pre-transplant experiences were significantly associated with current post-transplant psychological well-being and perceived ease of adherence among kidney transplant recipients in Kazakhstan. Waiting-related emotional burden showed the strongest adverse pattern of associations, including a direct association with poorer well-being and significant indirect associations with poorer well-being and lower perceived ease of adherence through health- and treatment-related anxiety. Anxiety represented an important intermediate statistical correlate within these modeled relationships. Transplant-related awareness was positively associated with well-being, while satisfaction with pre-transplant care showed a mixed pattern of associations with awareness, anxiety, and perceived ease of adherence. Because the study was cross-sectional, these findings do not establish temporal sequencing or causal mediation. Nevertheless, they support further prospective evaluation of psychosocial screening, structured patient education, and anxiety-focused support across the transplant trajectory.

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Ethics approval consent to participate: The study followed the Declaration of Helsinki and was approved by the Local Bioethics Commission of the “University Medical Center” (Protocol No. 3, 14 July 2023). All participants gave informed consent online or by phone after receiving full study information. Data were collected anonymously, securely stored, and participation was voluntary, with no risk or consequences for withdrawal.

Data availability statement: All raw data underlying the findings of this study can be obtained from the corresponding author upon reasonable request.

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* These authors contributed equally and are co-first authors.

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