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A comparative study of decision tree and logistic regression models in identifying factors influencing postoperative follow-up completion for arteriovenous fistula: a retrospective cohort study

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Title Page

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A comparative study of decision tree and logistic regression models in identifying factors influencing postoperative follow-up completion for arteriovenous fistula: a retrospective cohort study

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Abstract

Background

Postoperative follow-up is essential for maintaining arteriovenous fistula (AVF) function in maintenance hemodialysis (MHD) patients, yet completion rates remain suboptimal. Determinants of follow-up adherence are multifactorial and may involve interactions that traditional regression models fail to capture. This study aimed to identify factors influencing post-AVF follow-up completion and to compare the predictive performance of logistic regression and decision tree modeling.

Methods

We conducted a retrospective single-center cohort study of 818 MHD patients who underwent AVF creation between January 2023 and December 2024. Follow-up completion rate was calculated as attended visits divided by scheduled visits, and patients were dichotomized at the median rate (60%). Candidate predictors were entered into a binary logistic regression (Enter method) and a classification and regression tree (CRT) model. Model discrimination was compared using ROC-AUC and the DeLong test.

Results

The mean follow-up completion rate was 62.9% (median 60.0%). Logistic regression identified seven independent factors favoring higher completion: age ≥60 years (OR = 1.596), senior high school education (OR = 1.751), urban residence (OR = 1.716), monthly household income of 4001–6000 CNY (OR = 1.849), receiving hemodialysis at the surgical center (OR = 1.563), number of post-AVF reinterventions (OR = 3.015),

and higher MBI score (OR = 1.027). The CRT model achieved a higher AUC than logistic regression (0.762 vs. 0.693, DeLong $P < 0.001$). The Modified Barthel Index was the primary splitting variable, followed by reinterventions, residence, education, income, and age, revealing hierarchical interaction pathways.

Conclusions

Follow-up adherence after AVF creation is multifactorial. CRT modeling provides superior risk stratification and reveals interaction structures invisible to logistic regression. Reinterventions and urban residence drive adherence, whereas functional impairment and rural residence identify vulnerable subgroups. These findings support targeted, risk-stratified interventions to improve long-term AVF outcomes.

Trial registration：Not applicable.

Keywords

Arteriovenous fistula; Hemodialysis; Follow-up studies; Logistic models; Decision tree.

Background

Chronic kidney disease (CKD) poses a significant global health burden, with a substantial proportion of patients progressing to end-stage kidney disease (ESKD) requiring maintenance hemodialysis (MHD) [1-3]. Reliable vascular access is the cornerstone of effective hemodialysis, and the autogenous arteriovenous fistula (AVF) is the preferred option due to its superior long-term patency, lower complication rates, and minimal disruption to patients' daily lives compared to other access types[4]. However, unlike many vascular procedures aimed at correcting pathology, AVF creation involves constructing a novel vascular circuit whose functional success cannot

be fully ascertained intraoperatively. Consequently, systematic postoperative assessment and long-term follow-up are critical not only for monitoring maturation and detecting early dysfunction but also for guiding timely interventions to preserve patency[5].

Recognizing this importance, both international and national guidelines, including the KDOQI 2019 Update and the Chinese Dialysis Access Guidelines (2024 Edition), have established structured follow-up protocols post-AVF creation. These emphasize immediate postoperative assessment and lifelong periodic surveillance, with the first six months considered a critical period for fistula maturation and long-term patency[6, 7]. Despite this consensus, existing research has predominantly focused on clinical endpoints such as surgical success, thrombosis, stenosis, and patency rates. There remains a notable gap in the systematic investigation of patient adherence to follow-up schedules and the determinants of follow-up completion rates [8]. In the context of China's rapidly expanding dialysis population—which reached approximately 750,000 by 2021[9]—suboptimal follow-up completion not only jeopardizes individual patient outcomes but also escalates healthcare expenditures and strains the medical system[10]. Enhancing follow-up adherence through actionable process optimization has thus emerged as a major challenge in AVF management.

To address this gap, this study shifts focus from traditional clinical endpoints to the process indicator of postoperative follow-up completion—an often-overlooked aspect of long-term AVF care. We conducted a multidimensional analysis of factors influencing follow-up adherence among MHD patients, encompassing

sociodemographic characteristics, healthcare support, treatment-related factors, and functional status, aiming to identify high-risk subgroups and inform targeted interventions. Methodologically, logistic regression effectively identifies main effects but handles interactions poorly, whereas decision tree modeling naturally manages covariance through logical splits but may produce unstable classifications. We therefore combined both approaches to leverage their complementary strengths and lay an empirical foundation for personalized intervention strategies.

Materials and Methods

Research Design

A retrospective cohort study was conducted by reviewing the medical records of patients who underwent arteriovenous fistula (AVF) creation at our institution. A multistage data sampling and verification process was employed to ensure data quality.

Participants

The initial sample comprised 1,005 patients who underwent AVF creation between January 2023 and December 2024. Participants were recruited from the hemodialysis and vascular access follow-up databases. Inclusion criteria were as follows: (a) aged ≥18 years; and (b) having undergone AVF creation surgery at our center.

Exclusion criteria were as follows: (a) transferred follow-up care to other institutions; (b) received a kidney transplant during the follow-up period; (c) deceased during follow-up; (d) medical records with critical data missing. After applying the criteria, 818 patients were included in the final analysis.

Data Collection and Management

Data were extracted from two primary sources: the Hemodialysis Management System and the dedicated Vascular Access Follow-up Database. A comprehensive review of electronic medical records (EMRs) was conducted to collect detailed baseline characteristics and longitudinal clinical parameters. The data collection was performed over a two-month period by a trained research assistant in collaboration with a clinical informatics specialist. Following a predefined and piloted protocol, all data were meticulously entered into standardized electronic case report forms (e-CRFs), ensuring structured data capture. To guarantee accuracy and reliability, the principal investigator performed independent verification by cross-checking a randomly selected 10% of the entries against the original EMRs and source documents. Any discrepancies were resolved through consensus discussion.

Follow-up Protocol and Grouping Criteria

The patient follow-up protocol was structured according to the KDOQI Clinical Practice Guidelines for Vascular Access: 2019 Update and the Chinese Guidelines for Dialysis Access (2024 Edition)[6, 7] , with specific adaptations for local clinical workflows:(a) Immediate Postoperative Phase (Within 1 week): Focused on monitoring for surgical complications (e.g., hemorrhage, infection) and initial assessment of vascular patency.(b) Early Maturation Phase (Weeks 1–4): Patients were instructed on regular exercise of the fistula limb and daily self-palpation to assess thrill. A preliminary cannulation plan was formulated based on vessel development. (c) Maturation Assessment Phase (Weeks 4–8): Ultrasound assessment of blood flow volume and vessel diameter was conducted to evaluate AVF maturation status. Cannulation was

initiated upon meeting predefined criteria (e.g., flow >500 mL/min, diameter >6mm, subcutaneous depth <6mm). (d)Long-term Maintenance Phase: Scheduled routine follow-up visits at 3,6, 12and 24 months post-creation. The follow-up interval was dynamically adjusted if access-related interventions (e.g., angioplasty, thrombectomy) were required, effectively resetting the follow-up schedule.

The primary outcome, individual follow-up completion rate, was calculated as: (Number of attended follow-up visits / Number of planned follow-up visits according to protocol) × 100%. Patients who experienced AVF failure (defined as thrombosis, stenosis, or infection requiring abandonment of the access) were not censored from the analysis. Their follow-up visits related to the failed access up to the point of failure were included in the calculation of their individual completion rate, as these visits represent adherence to the surveillance protocol. Patients who underwent a new AVF creation procedure during the study period were considered to have a new index event, and their follow-up schedule was reset accordingly for the purpose of calculating the completion rate for the new access.

Study Measures and Instruments

Demographic, Clinical and Functional Characteristics

Collected variables included:(a) Demographics: gender, age, educational level, marital status, residential area (urban/rural), primary caregiver, employment status, monthly household income per capita, and type of medical insurance.(b) Clinical Characteristics: primary dialysis modality (hemodialysis or peritoneal dialysis), whether hemodialysis was performed at our center, dialysis vintage, etiology of end-stage renal disease,

number of comorbidities, AVF initiation status (whether initiated as scheduled), and frequency of post-AVF reinterventions.

Modified Barthel Index (MBI)

Activities of daily living (ADL) were assessed using the Modified Barthel Index (11).. This scale comprises ten items evaluating basic self-care (feeding, grooming, bathing, dressing, bowel and bladder control) and mobility (transfers, ambulation, stair climbing). Total scores range from 0 (complete dependence) to 100 (complete independence). The scale demonstrates excellent internal consistency (Cronbach's α = 0.92) in relevant populations.

Family APGAR Index

Family function and support were evaluated using the Family APGAR Index (12). This 5-item instrument measures five dimensions: Adaptation, Partnership, Growth, Affection, and Resolve. Each item is scored on a 3-point Likert scale (0=never, 1=sometimes, 2=often). The total score (0-10) categorizes family function as: 7-10 (highly functional), 4-6 (moderately dysfunctional), and 0-3 (severely dysfunctional). It has good test-retest reliability (r=0.80–0.83) and has been validated in Chinese chronic disease populations.

Data analysis

As this was a retrospective cohort study based on available medical records, no a priori sample size or power calculation was performed. All statistical analyses were performed using SPSS 27.0. Continuous variables were tested for normality via the Shapiro–Wilk test; normally distributed data are presented as mean ± SD, while

non-normally distributed data as median (IQR). Categorical variables are expressed as frequencies (%). Participants were divided into high- and low-follow-up completion groups using the median completion rate (60%). For group comparisons, categorical variables were analyzed using the χ^2 test (or Fisher's exact test when expected frequencies <5), and continuous variables (non-normal) using the Mann–Whitney U test.

Variables with $P<0.05$ in univariate analysis were simultaneously entered into a binary logistic regression model using the Enter method (forced entry), without stepwise selection. Multicollinearity was assessed using variance inflation factors (VIF >10 indicated collinearity), and model calibration was evaluated by the Hosmer–Lemeshow test ($P>0.05$ indicated good fit). Concurrently, a classification decision tree was constructed using the CRT algorithm in SPSS, with Gini impurity as the splitting criterion. The split significance was set at 0.05, with minimum parent/child node sizes of 100 and 50, respectively; tree depth was not limited.

Discriminative performance was assessed using ROC curve analysis (AUC with 95% CI), and AUCs were compared using the DeLong test. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated at a probability threshold of 0.5. All tests were two-sided, with $P<0.05$ considered statistically significant.

Results

General characteristics and postoperative follow-up completion status of the study population

This study enrolled 818 maintenance hemodialysis patients who underwent arteriovenous fistula (AVF) creation. The mean age was 57.71 ± 13.30 years, with 61.2% being male and 68.6% residing in rural areas. Regarding marital status, the majority were married (92.4%). In terms of education, 30.9% had primary school or below, 34.0% had junior high school, 23.3% had senior high school/secondary school, and 11.7% had college or above. The majority of patients were unemployed (82.5%). Monthly household income per capita was distributed as follows: 27.9% earned <2000 CNY, 36.1% earned 2000–4000 CNY, 23.7% earned 4001–6000 CNY, and 12.3% earned >6000 CNY. The primary caregivers were mainly spouses (60.9%), followed by children (21.5%), while 13.1% had no caregiver. Regarding health insurance, 61.9% had urban resident insurance, 15.9% had New Rural Cooperative Medical Scheme, 12.2% had employee insurance, 9.8% had no insurance, and 0.2% had commercial insurance. A total of 16.4% of patients underwent hemodialysis at a dialysis center, and AVF was initiated as scheduled in 71.4% of cases. The mean follow-up completion rate was 62.90 ± 29.88%, with a median of 60%.

Comparison of Follow-up Completion Rates after AVF Creation among Maintenance Hemodialysis Patients with Different Characteristics

Table 1 presents the characteristics of the participants categorized by their follow-up completion status. Participants were divided into a low-completion group (n = 457) and a high-completion group (n = 361). Significant inter-group differences were found in age, education, residence, employment, monthly household per-capita income, hemodialysis at our center, scheduled AVF initiation, post-AVF reinterventions, and

MBI score (all $P < 0.05$).

Table 1. Comparison of Characteristics between Patients with Low and High Follow-up Completion Rates

Characteristic	Low Completion Group (n=457)	High Completion Group (n=361)	χ^2/Z	P value
Gender			0.727[a]	0.394
Men	274(60.0%)	227(62.9%)		
Women	183(40.0%)	134(37.1%)		
Age (years)			14.131[a]	< 0.001
< 60	268 (58.6)	164 (45.4)		
≥60	189 (41.4)	197 (54.6)		
Educational level			9.132[a]	0.028
Primary school or below	155 (33.9%)	98 (27.1%)		
Junior high school	159 (34.8%)	119 (33.0%)		
Senior high school / secondary school	90 (19.7%)	101 (28.0%)		
College or above	53 (11.6%)	43 (11.9%)		
Marital status			1.862[a]	0.602
Married	418 (91.5%)	338 (93.6%)		
Single	18 (3.9%)	10 (2.8%)		
Divorced	12 (2.6%)	9 (2.5%)		
Widowed	9 (2.0%)	4 (1.1%)		
Residential area			18.797[a]	< 0.001
Rural	342 (74.8%)	219 (60.7%)		

Characteristic	Low Completion Group (n=457)	High Completion Group (n=361)	χ^2/Z	P value
Urban	115 (25.2%)	142 (39.3%)		
Primary caregiver			9.958[a]	0.062
Spouse	259 (56.7%)	239 (66.2%)		
Child	106 (23.2%)	70 (19.4%)		
Nanny/Carer	10 (2.2%)	4 (1.1%)		
Other	16 (3.5%)	7 (1.9%)		
None	66 (14.4%)	41 (11.4%)		
Employment status			4.077[a]	0.043
Yes	69 (15.1%)	74 (20.5%)		
No	388 (84.9%)	287 (79.5%)		
Monthly household income per capita			8.523[a]	0.036
< 2000 CNY	136 (29.8%)	92 (25.5%)		
2000~4000 CNY	170 (37.2%)	125 (34.6%)		
4001~6000 CNY	91 (19.9%)	103 (28.5%)		
> 6000 CNY	60 (13.1%)	41 (11.4%)		
Medical insurance			0.478[a]	0.976
Urban and Rural Resident Basic Medical Insurance	286 (62.6%)	220 (60.9%)		
New Rural Cooperative Medical Insurance	73 (16.0%)	57 (15.8%)		
Commercial Medical Insurance	1 (0.2%)	1 (0.3%)		
None	44 (9.6%)	36 (10.0%)		

Characteristic	Low Completion Group (n=457)	High Completion Group (n=361)	χ^2/Z	P value
Urban Employee Basic Medical Insurance	53 (11.6%)	47 (13.0%)		
HD at our center			7.996[a]	0.005
Yes	60 (13.1%)	74 (20.5%)		
No	397 (86.9%)	287 (79.5%)		
AVF initiated as scheduled			4.943[a]	0.026
Yes	312 (68.3%)	272 (75.3%)		
No	145 (31.7%)	89 (24.7%)		
Number of comorbidities [Median (IQR)]	2.0(1.0,3.0)	2.0(1.0,3.0)	-0.112[c]	0.911
Post-AVF Reinterventions [Median (IQR)]	0.0(0.0,0.0)	1.0(1.0,1.0)	-5.600[c]	< 0.001
Family APGAR Score [Median (IQR)]	10.0(8.0,10.0)	10.0(8.0,10.0)	-1.369[c]	0.171
Modified Barthel Index Score [Median (IQR)]	80.0(76.0,84.0)	84.0(81.0,84.0)	-9.844[c]	< 0.001

Abbreviations: CNY, Chinese Yuan; AVF, arteriovenous fistula; SD, standard deviation; HD, Hemodialysis.

[a] Chi-square test. [b] Fisher's exact test. [c] Mann-Whitney U test.

Logistic regression analysis

Follow-up completion status was the dependent variable (Low = 0, High = 1). Nine variables significant in univariate analyses (age, education, residence, employment, monthly household per-capita income, hemodialysis at our center, scheduled AVF

initiation, post-AVF reinterventions, and MBI score) were entered into a binary logistic regression model using the Enter method. The Hosmer–Lemeshow test indicated good calibration ($\chi^2 = 6.500$, df = 8, P = 0.591), and the omnibus test confirmed overall significance ($\chi^2 = 102.010$, df = 13, P < 0.001), with a Nagelkerke R^2 of 0.157. Seven independent protective factors were identified: age ≥ 60 years, senior-high-school education, urban residence, monthly per-capita income of 4001–6000 CNY, hemodialysis at our center, more post-AVF reinterventions, and higher MBI score ($P < 0.05$).The corresponding regression coefficients, odds ratios, and 95% confidence intervals for these factors are provided in Table 2.

Table 2: Dichotomous Logistic Regression Analysis of Factors Influencing Follow-up Completion Rates after AVF Creation (n=818)

Variable	*B*	*SE*	*Wald χ2*	*P*	*OR*	*95% CI*
Age						
≥60 years (Ref. <60 years)	0.467	0.153	9.382	0.002	1.596	1.183–2.152
Educational level (Ref: Primary school or below)			7.392	0.060		
Junior high school	0.196	0.190	1.058	0.304	1.216	0.838–1.766
Senior high school / secondary school	0.560	0.209	7.200	0.007	1.751	1.163–2.636
College or above	0.170	0.260	0.425	0.515	1.185	0.711–1.973
Residential area (Ref: Rural)						
Urban	0.540	0.163	10.977	< 0.001	1.716	1.247–2.363
Employment status (Ref: No)						
Yes	0.359	0.199	3.247	0.072	1.432	0.969–2.116

Variable	*B*	*SE*	*Wald χ2*	*P*	*OR*	*95% CI*
Monthly household income per capita (Ref: <2000 CNY)			10.360	0.016		
2000–4000 CNY	0.097	0.192	0.255	0.613	1.102	0.756–1.605
4001–6000 CNY	0.615	0.211	8.514	0.004	1.849	1.224–2.794
>6000 CNY	0.062	0.259	0.058	0.809	1.064	0.641–1.768
HD at our center (Ref: No)						
Yes	0.446	0.204	4.765	0.029	1.563	1.047–2.333
AVF initiated as scheduled (Ref: No)						
Yes	0.186	0.168	1.219	0.270	1.204	0.866–1.675
Number of post-AVF reinterventions	1.103	0.221	24.891	<0.001	3.015	1.954–4.651
Modified Barthel Index Score	0.026	0.008	9.698	0.002	1.027	1.010–1.044
Constant	-3.528	0.698	25.515	<0.001	0.029	—

Abbreviations: B, regression coefficient; SE, standard error; OR, odds ratio; CI, confidence interval; Ref, reference category; HD, hemodialysis; AVF, arteriovenous fistula.

Notes: The dependent variable was follow-up completion status (High Completion Group = 1, Low Completion Group = 0).

Decision Tree Modelling Analysis of Factors Influencing Follow-up Completion Rates in Maintenance Hemodialysis Patients after AVF Creation

A CRT model was built using the Gini coefficient (splitting significance 0.05; minimum parent/child node sizes 100/50). Only variables significant in univariate analyses were included. As shown in Figure 1, the Modified Barthel Index (MBI) score was the primary splitting variable (improvement = 0.081), showing the strongest predictive

power. Patients scoring ≤ 83.5 had a high rate of low follow-up completion (74.9%), whereas those scoring > 83.5 were more likely to achieve high completion (65.4%). Within this subgroup, reinterventions became the next split factor, with 1–3 reinterventions showing the highest completion (84.7%). For patients without reinterventions, residential area, education, income, and age were selected sequentially. Higher completion was observed among urban residents, patients aged ≥ 60 years, rural participants with senior-high-school education, and those with a monthly per-capita income of 4001–6000 CNY, whereas low-income rural residents showed worse adherence.

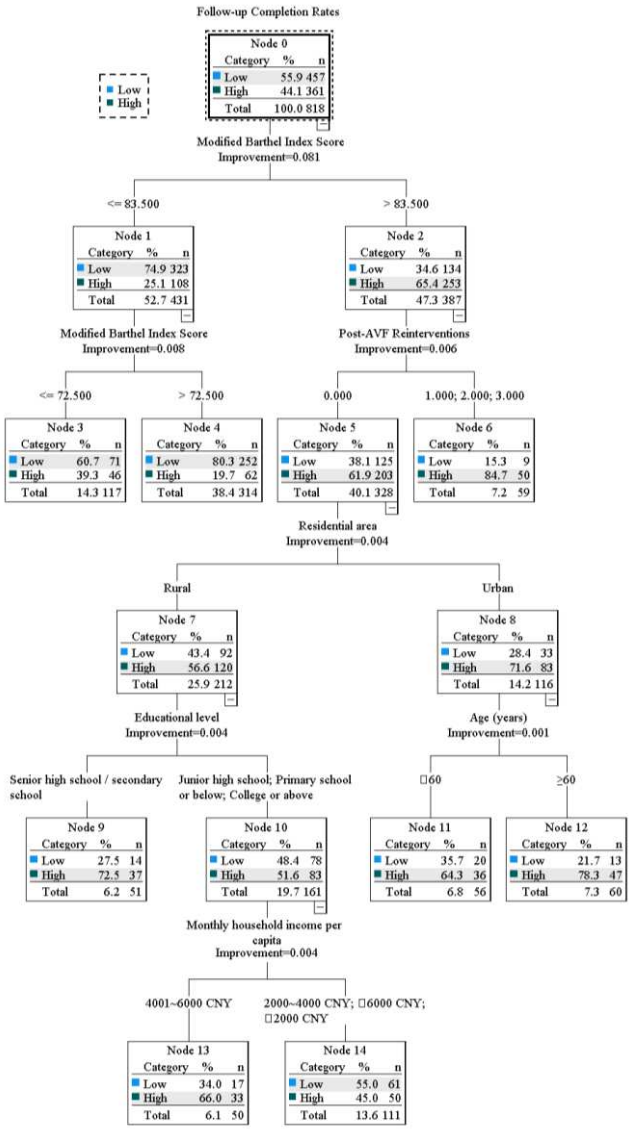


Fig. 1 Decision Tree Model of Factors Influencing Follow-up Completion Rates after AVF Creation

Comparison of the decision tree model and logistic regression model

Predictive performance was compared using ROC curves (Fig. 2). As shown in Table 3, the decision tree model achieved a higher AUC than logistic regression, indicating superior discriminative ability, with a statistically significant difference ($Z = -3.362$, $P < 0.001$). At a threshold of 0.5, logistic regression showed a sensitivity of 66.8% and

specificity of 60.6%, whereas the decision tree showed a lower sensitivity of 46.3% but a higher specificity of 79.2%.

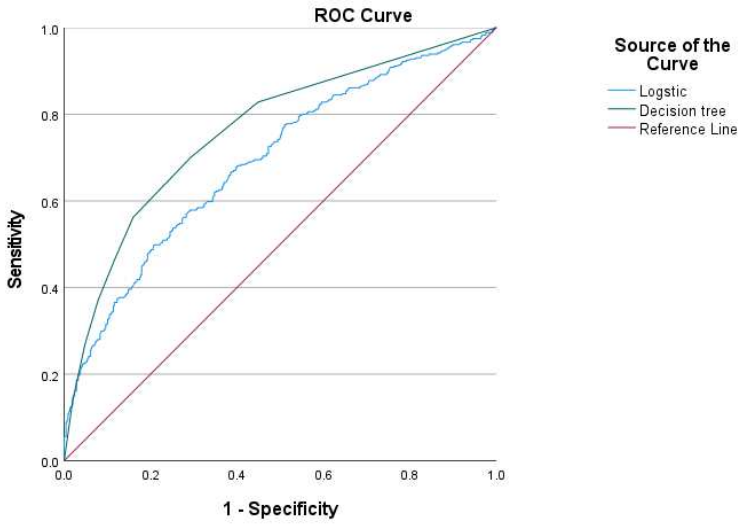


Fig. 2 ROC curve**s for the logistic regression and decision tree models**

Table 3 Comparison of the classification effects of the logistic regression and decision tree models

Model	AUC	*SE*	*P*	*95% CI*
Logistic regression	0.693	0.019	0.000	0.656-0.729
Decision tree	0.762	0.017	0.000	0.729-0.795

Discussion

This study investigated determinants of postoperative follow-up completion after arteriovenous fistula creation in maintenance hemodialysis patients, using both logistic regression and classification and regression tree modeling. The mean completion rate was only 62.90% (median 60.0%), indicating substantial room for improvement in long-term AVF care.

Sociodemographic and Socioeconomic Determinants

Our findings underscore the profound impact of social determinants on healthcare engagement. Urban residents had significantly higher follow-up completion rates than rural counterparts (adjusted OR = 1.716, 95% CI: 1.247–2.363; P < 0.001). This disparity likely mirrors the uneven distribution of healthcare resources in China, where geographic distance, transportation challenges, and limited access to specialized dialysis-related care in rural regions create tangible barriers to consistent follow-up attendance[13, 14]. In the decision tree model, residential area further stratified patients within the no-reintervention subgroup: among rural participants without reinterventions, those with lower educational attainment exhibited lower completion rates, suggesting a compounding disadvantage of rural residence and limited health literacy. Conversely, urban residence partially offset the negative effect of low education, possibly due to better healthcare accessibility and higher awareness of preventive care [15].

Educational level also emerged as an independent protective factor, with senior high school/secondary school education conferring significantly higher odds of high follow-up completion compared with primary school or below (OR = 1.751, 95% CI: 1.163–2.636), independent of income. Although not directly assessed in this study, this association is plausibly mediated by health literacy, which is closely tied to educational attainment and facilitates better comprehension of surveillance rationales and healthcare navigation[16]. The plateau at the senior high school level, without additional benefit from college education, suggests that this level of literacy may be sufficient for understanding follow-up instructions, and further education does not proportionally translate into additional behavioral compliance. This finding identifies patients with

primary education or below as a priority subgroup for literacy-sensitive interventions (e.g., simplified instructions and reminder calls) in clinical practice.

Regarding household income, only the 4001–6000 CNY per capita bracket demonstrated a significant independent effect (OR = 1.849, 95% CI: 1.224–2.794), while lower and higher brackets did not show statistical significance. This non-linear pattern might be partly influenced by the uneven distribution of sample sizes across income strata, where the highest income group had relatively fewer cases, limiting the power to detect a significant difference. Employment status, although significant in univariate analysis (P = 0.043), lost significance in the multivariable model (P = 0.072). This attenuation is most likely attributable to collinearity with income and education, given that employment status is closely intertwined with these socioeconomic indicators. Similarly, age ≥ 60 years emerged as an independent positive predictor (OR = 1.596, P = 0.002). While this may reflect generally better medication adherence or routine healthcare utilization among retired older adults, this mechanism is speculative based on the current dataset and warrants further investigation.

Healthcare Resource Utilization and Treatment-Related Factors

Receiving hemodialysis at the same center where the AVF was created significantly improved completion rates (OR = 1.563, P = 0.029). This finding highlights the benefits of integrated care delivery, including better care coordination (e.g., scheduling follow-up examinations on dialysis days), established patient–provider relationships, and continuous access to the vascular access team [17]. For patients dialyzing at external centers, fragmented communication and lack of a unified medical record may lead to

missed surveillance opportunities. This observation aligns with the growing emphasis on regionalized vascular access care networks in China [7].

The number of post-AVF reinterventions was the most powerful predictor of follow-up completion in both modeling approaches. In logistic regression, each additional reintervention increased the odds of high completion by more than threefold (OR = 3.015, 95% CI: 1.954–4.651; $P < 0.001$), and in the decision tree, it served as the second-level splitter among higher-functioning patients. This robust association likely reflects that patients requiring angioplasty or thrombectomy are embedded in a more intensive care cycle, with more frequent exposure to vascular access monitoring and coordinator-led patient education. Although reinterventions are clinically undesirable, they may paradoxically reinforce patient engagement with subsequent surveillance—a hypothesis that warrants further investigation.

Interestingly, AVF initiated as scheduled did not remain significant in the multivariate model ($P = 0.270$) despite its univariate association ($P = 0.026$), suggesting its effect is confounded by other clinical factors (e.g., access quality, functional status). This underscores the importance of comprehensive multivariable adjustment.

Functional Status: The Dominant Role of Physical Independence

The Modified Barthel Index (MBI) emerged as the most influential factor in the decision tree model, serving as the primary splitting variable. Patients with MBI scores ≤ 83.5 had a 74.9% probability of low follow-up completion, while those with scores > 83.5 were more likely to achieve high completion (65.4%). This striking contrast underscores the primacy of physical functional independence in shaping healthcare

engagement. In logistic regression, MBI also retained independent significance (OR = 1.027, 95% CI: 1.010–1.044; P = 0.002), confirming a consistent effect across approaches.

The mechanisms linking physical function to follow-up completion are multifaceted. Patients with impaired mobility face substantial practical obstacles—transportation difficulties, clinic navigation, and prolonged waiting times—that compound the daily burden of dialysis[18]. Additionally, functional decline often correlates with greater symptom burden and fatigue, which may diminish motivation for preventive care[19]. The decision tree further revealed the contextual interplay: among higher-functioning patients (MBI > 83.5), reintervention count became the dominant differentiator, whereas among lower-functioning patients, functional status alone accounted for most of the predictive power, with no subsequent splits reaching significance. This interaction—undetectable in logistic regression—provides actionable clinical insight: for patients with compromised physical function, interventions should prioritize accessibility and transport support.

Of note, the Family APGAR score did not reach statistical significance in univariate comparisons ($P = 0.171$) and was not selected in the decision tree. However, primary caregiver type approached significance ($P = 0.062$), with spouse- and child-caregiver groups showing numerically higher completion rates than those without caregivers. This suggests that the presence of a dedicated caregiver, rather than perceived family functioning quality, may be the more salient support dimension, possibly because practical assistance (transportation, appointment reminders) is more directly linked to

completion than emotional support alone[20].

Methodological Insights from Integrated Modeling

Logistic regression and CRT decision tree provided complementary insights. Logistic regression quantified each factor's net effect as ORs with 95% CIs, assessing individual contribution magnitude and precision. The decision tree, leveraging its strength in handling interactions, revealed hierarchical risk stratification—MBI as the primary classifier, followed by reintervention count among functionally intact patients, and further showing that among rural, low-MBI patients without reinterventions, education and income sequentially modified completion risk—insights unattainable from main-effects logistic regression.

For predictive performance, CRT achieved a higher AUC (0.762 vs. 0.693, DeLong $P < 0.001$). However, CRT showed lower sensitivity (46.3% vs. 66.8%) but higher specificity (79.2% vs. 60.6%) at the 0.5 threshold. Thus, CRT is more conservative in classifying high-completion patients—useful for identifying a clearly defined target subgroup—while logistic regression offers broader coverage with more false positives. Model selection should depend on clinical context and resource availability.

Conclusions

Follow-up completion after AVF creation in MHD patients was shaped by sociodemographic, healthcare, treatment, and—most importantly—functional status (MBI). Physical function served as the primary classifier, with reintervention history, residence, education, income, and age further refining risk profiles. CRT outperformed logistic regression in discrimination, and the strong reintervention–completion

association suggests that access dysfunction episodes may serve as "teachable moments" to reinforce surveillance. These findings support routine MBI screening, proactive support for rural and low-education patients, and risk-stratified intervention bundles, though the single-center retrospective design, residual confounding, and lack of external validation mean the results remain hypothesis-generating and warrant future prospective, multicenter and interventional validation.

List of abbreviations

Abbreviation	Full Term
ADL	Activities of Daily Living
AUC	Area Under the Curve
AVF	Arteriovenous Fistula
CKD	Chronic Kidney Disease
CI	Confidence Interval
CNY	Chinese Yuan
CRT	Classification and Regression Tree
EMRs	Electronic Medical Records
e-CRFs	Electronic Case Report Forms
ESKD	End-Stage Kidney Disease
HD	Hemodialysis
IQR	Interquartile Range
KDOQI	Kidney Disease Outcomes Quality

	Initiative
MBI	Modified Barthel Index
MHD	Maintenance Hemodialysis
OR	Odds Ratio
PI	Principal Investigator
ROC	Receiver Operating Characteristic
SD	Standard Deviation
SE	Standard Error
VIF	Variance Inflation Factor

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Clinical Research Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine ([2025B] IIT Ethics Approval No. 0713). The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study, which involved the analysis of anonymized clinical data.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to institutional restrictions and patient privacy concerns, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that there is no conflict of interest.

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Author's Contributions

Y. W. and Q.Y. are the co-first authors. Y.W. and Q.Y. performed conceptualization, methodology, investigation, data curation, formal analysis and writing – original draft. Q.Y. and M.X. performed investigation, data curation and validation. Z.H. performed investigation, data curation and formal analysis. Q.Y., M.X., Z.H., C.Y. and W.M. contributed to writing – review & editing. C.Y. and W.M. performed investigation and data curation. All authors reviewed the manuscript.

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