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Family and social functioning deficits in patients with colorectal cancer accompanied by stoma formation: a cross-sectional study examining the mediating role of social support

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Background: Patients with colorectal cancer and ostomy frequently experience deficits in social functioning, which may adversely affect their quality of life. Although family functioning and social support are recognized as factors associated with lower social functioning deficits, the mechanisms connecting these variables remain unclear. The present study examined whether social support mediates the association between family functioning and social functioning deficits.

Methods: A cross-sectional survey was performed among 297 patients with CRC and an ostomy, selected by convenience sampling between September 2025 and July 2026. Data were obtained using the Social Dysfunction Screening Scale, the Family APGAR Index, and the Social Support Rating Scale. Spearman correlation, multiple linear regression, and bootstrap mediation analyses were conducted.

Results: Both family functioning and social support showed significant associations with social functioning deficits and together explained 91.0% of the variance. Family functioning was positively related to social support ($\beta = 0.836$, $P < 0.001$), which in turn was inversely associated with social functioning deficits ($\beta = -0.421$, $P < 0.001$). The indirect effect through social support was significant (standardized $\beta = -0.352$, 95% CI: -0.422 to -0.284) and accounted for 40.0% of the total effect. However, substantial measurement overlap among the three scales warrants cautious interpretation of this statistical indirect association.

Conclusions: Social support was associated with the relationship between family functioning and social functioning deficits. Family functioning was both directly and indirectly associated with social functioning through social support; however, substantial measurement overlap warrants cautious interpretation. These findings suggest that family functioning and social support are closely intertwined with social functioning in patients with colorectal cancer and a stoma, but longitudinal or intervention studies are needed to confirm any causal or interventional benefits.

KEYWORDS

colorectal cancer, family functioning, mediating effect, social functioning deficits, social support, stoma

1 Introduction

Colorectal cancer (CRC), which represents around 10% of global cancer incidence, is the third most common cancer and the second leading cause of cancer deaths (1). Surgical resection combined with stoma creation is an important treatment approach intended to prolong survival; however, it can alter body image and reduce social functioning, resulting in emotional distress and eventually social functioning deficits (2, 3). According to the International Classification of Functioning, Disability and Health (ICF), social functioning belongs to the category "Activities and Participation" and involves interpersonal interactions, social activities, and work (4). Social functioning deficits reflect inadequate integration of cognitive, emotional, and behavioral functions to respond appropriately to social situations, which may manifest as a lack of interest, social withdrawal, and a decline in daily living and occupational abilities (5, 6). Patients with colostomies may experience feelings of repulsion, social withdrawal, loneliness, and irritability due to changes in body image, uncontrolled defecation, or leakage of the stoma bag (7). According to the ICF framework, social functioning deficits are associated with not only with reduced physical function but also by personal factors (e.g., age, sex, resilience) and environmental factors (e.g., family support, public attitudes, healthcare resources).

Substantial attention has focused on the high prevalence of social functioning deficits in CRC stoma patients. For instance, Xiao et al. (8) reported that 80.16% of patients had social functioning deficits, while Zhang et al. (9) found that 91.8% had not returned to their baseline levels of social functioning after disease onset, and a similar study conducted by Gautam et al. (10) in Nepal found similar results. In a longitudinal study of 131 CRC stoma patients, Wang et al. (11) reported an overall improvement in social functioning after surgery, although substantial individual variation remained. Psychological resilience was significantly associated with social functioning deficits (OR = 19.39, 95% CI: 2.46 to 152.91, P < 0.05). Such deficits may reduce quality of life while increasing the burden of family caregiving and healthcare costs (12, 13). Qualitative evidence further indicates that CRC stoma patients experience a postoperative adjustment process involving a redefinition of bodily autonomy and privacy boundaries (14). Because the ICF model highlights potentially important mediating roles of personal and environmental factors (15), more attention should be given to how modifiable environmental factors shape social functioning deficits.

Family functioning is an important factor associated with social functioning deficits in the social environment and reflects the capacity of the family system to preserve cohesion, communicate effectively, and respond to stress (16). Among 282 patients with CRC with permanent stomas, Li et al. (17) found that family functioning significantly moderated the indirect association between psychological distress and quality of life, and the indirect association weakened as family functioning improved. Qualitative studies have identified "family crisis caused by stoma formation" as a central vulnerability factor, with both patients and spouses experiencing prolonged psychological stress and diminished social interaction (18). Xu et al. (19) further identified poor family functioning as an important factor associated with social dysfunction. In addition, previous studies suggest that family reciprocity enhances resilience through improved family functioning (20). Furthermore, systematic reviews also show that a relationship exists between good family functioning and social functioning in CRC stoma patients (21).

Social support, defined as emotional, instrumental, and informational support provided by one's social network, is another factor consistently associated with social functioning (22). Perceived social support was identified as the strongest predictor of loneliness in cancer patients (OR = 0.69), according to Fernández-Rodríguez et al. (23). Furthermore, Karadede and Rizalar (24) demonstrated that higher levels of perceived informational support were associated with less anxiety. In 240 CRC stoma patients, Zhao and Yao (25) reported a significant inverse correlation between social functioning and social support scores ($r_s = -0.62$, $P < 0.001$). Liang et al. (26) also found that social support was strongly associated with psychological resilience and clarity of self-concept, while insufficient external support negatively affected social adaptation. He (27) further demonstrated a dynamic relationship between social functioning and psychological resilience, with social support having an important role in this interaction.

Support from family members, especially spouses and children, may assist patients in overcoming stoma-related shame and avoidance and encourage them to actively seek external support (19, 28). Conversely, poor family functioning may promote patients' isolation from broader social networks. Xin et al. (29) reported a synergistic association of family functioning and social support on quality of life. However, the underlying mechanism, particularly whether social support mediates the pathway from family functioning to social functioning deficits, has yet to be systematically examined.

Roy's Adaptation Model was therefore adopted as the theoretical framework. The model conceptualizes adaptation as a sequential process: Input (stimulus) → Control Process (coping mechanism) → Effectors (adaptive modes) → Output (adaptation outcome) (30). Interventions based on this model have been shown to reduce anxiety and depression and improve quality of life in patients with colostomy (31). In the present study, CRC diagnosis and stoma type were considered input stimuli, family functioning and social support as components of the control process, and social functioning status as the adaptation outcome. Accordingly, social support was hypothesized to mediate the association between family functioning and social functioning outcomes.

2 Methods and research approach

2.1 Study design

This cross-sectional survey was performed from September 2025 to July 2026 in the Stoma Clinic at the Affiliated Hospital of Guangdong Medical University, encompassing the Gastrointestinal Surgery Department, the Proctology Department, and the Digestive Oncology Department. These units were selected based on

accessibility and willingness to take part. Participants were patients with colorectal cancer and a stoma who met the inclusion criteria and were chosen by convenience sampling. A total of 320 questionnaires were distributed, of which 297 valid questionnaires were collected, resulting in a valid response rate of 92.8%. The present study was reviewed and authorized by the Ethics Committee of the Affiliated Hospital of Guangdong Medical University (Approval Number: KT2026-042-01) before participant recruitment. All procedures were performed in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants.

2.2 Study subjects

Inclusion criteria: (1) Age ≥ 18 years; (2) Meeting the diagnostic criteria for colorectal cancer as defined in the WHO International Classification of Diseases, ICD-10; (3) Having undergone intestinal ostomy with a postoperative interval of ≥ 1 month; (4) Having clear consciousness and normal communication abilities; (5) Providing informed consent and agreeing to participate voluntarily in this study.

Exclusion criteria: (1) Patients who were unaware of their diagnosis at the request of their families; (2) Patients with concurrent severe comorbidities; (3) Individuals with severe mental illness or communication impairments.

2.3 Sample size estimation

Previous research reported a prevalence of 80.16% for social functioning deficits among patients with colorectal cancer who had undergone stoma surgery (8). The necessary sample size was estimated using the sample size formula for cross-sectional studies (32): $n = (Z\alpha/2)2 \times P(1 - P) \ /\delta 2$, with α=0.05, $Z\alpha/2$ = 1.96, and an acceptable error of δ=0.05; the calculation indicated a minimum of 244 participants. After allowing for a 10% loss to follow-up, the required sample increased to 269. A total of 297 subjects were recruited in the present study, providing a sufficient sample for statistical analysis. This sample also satisfied the requirement for mediation effect testing because Fritz and MacKinnon (33) recommended at least 200 cases for a moderate effect size.

2.4 Research tools

2.4.1 General information questionnaire

Following a review of relevant literature, a general information questionnaire was developed to obtain data on the following characteristics: patient age, gender, place of residence, marital status, educational level, occupation type, number of children, main postoperative caregiver, monthly household income per person, return-to-work status postoperatively, healthcare payment method, disease stage, time since surgery, history of radiotherapy and chemotherapy, stoma type, self-care ability, and postoperative complications.

2.4.2 Social dysfunction screening scale

The WHO Disability Assessment Schedule was originally developed by the World Health Organization and modified and translated by Xu (34) to assess social functioning in individuals. The scale consisted of 10 items: occupation, marriage, parenting, social interaction, out-of-home activity, in-home activity, family life, personal care, hobbies/interests, and responsibility/planning. A three-point response scale was used (0 = no disability, 1 = some disability, 2 = severe disability), with a score of 9 indicating not applicable. According to the scoring method, items rated as "not applicable" were omitted from the total score. As the number of applicable items differed across participants (e.g., occupation, marital, and parental items were not applicable to unmarried or childless participants), a pro-rated score was computed as (sum of applicable items/number of applicable items) × 10. The pro-rated score ranged from 0 to 20, with higher scores reflecting greater social functioning deficits.

Applicability was assessed at the item level. There were no missing responses for applicable items; all non-applicable items were structurally inapplicable. The first three items were not universally applicable: the "occupation" item was not applicable to participants who were retired, unemployed, or students; the "marriage" item was not applicable to 36 unmarried, divorced, or widowed participants; and the "parenting" item did not apply to 21 participants without children. The other seven items applied to all 297 participants. Among the 297 participants, 122 completed all 10 items and were used for the reliability analysis. The remaining 175 participants had at least one inapplicable item (occupation, marriage, or parenting), and some had more than one. All 297 participants were included in the main analyses using pro-rated scores. In the present study, the Cronbach's α value of the scale was 0.752, estimated from 122 participants who completed all applicable items. All main analyses (correlation, regression, and mediation) used the pro-rated SDSS scores from all 297 participants. The reliability analysis was restricted to the 122 participants who completed all 10 items. A sensitivity analysis restricted to the seven universally applicable items yielded consistent results (Supplementary Table S2).

2.4.3 Family APGAR index

This scale was initially developed by Smilkstein, Ashworth and Montano (35) in 1978 and comprises five items: Adaptability, Partnership, Growth, Affection, and Responsibility. The Chinese version was translated and revised by Lü, Zeng (36) and has been widely used for assessment of family functioning in Chinese populations. A three-level rating system was used (0 = rarely; 1 = sometimes; 2 = frequently). The overall score ranged from 0 to 10. Family functioning was classified as severely impaired if the score was ≤3, moderately impaired if the score was between 4 and 6, and unimpaired if the score was ≥7. In this study, the scale yielded a Cronbach's α of 0.731.

2.4.4 Social support rating scale

This scale was originally developed by Xiao (37). It comprises 10 items organized into three domains: objective support (3 items), subjective support (4 items), and active support utilization (3 items). The total score ranged from 12 to 66, with higher scores indicating a higher level of social support. In the present study, the Cronbach's α value of the scale was 0.799.

2.5 Data collection and quality control

Before questionnaire administration, the project was approved by the Ethics Committee of the hospital and the relevant departments. After written informed consent was obtained from eligible patients, questionnaires were distributed by trained researchers, who described the purpose of the study. Questionnaires were completed and collected on-site. When necessary, researchers assisted participants in completing the questionnaires. The main reasons for assistance were age-related visual decline, limited literacy or difficulty understanding certain items, and postoperative weakness, fatigue, or discomfort. Assistance was limited to reading items aloud, clarifying wording, and verifying that responses were accurately recorded. Each answer was confirmed with the participant, and researchers did not guide or influence participants' choices. The frequency of assistance was not systematically recorded as a separate variable in the dataset, which prevented a formal comparison between assisted and independent completions. Two researchers entered the data independently into Excel. Once data accuracy had been verified, the data were imported into SPSS 27.0 for analysis.

2.6 Statistical analysis

All analyses used the pro-rated SDSS scores from all 297 participants, except where otherwise specified. SPSS 27.0 was employed for statistical analysis. Normality tests (Shapiro-Wilk test) were performed for the quantitative data. Because the total SDSS (pro-rated), APGAR, and SSRS scores did not follow a normal distribution ($P < 0.05$), the Mann-Whitney U test was used to compare two groups, the Kruskal-Wallis H test was applied to comparisons among multiple groups, and the Bonferroni method was used to adjust pairwise comparisons between groups. Spearman correlation analysis was employed for assessment of correlations between variables. Variables with $P < 0.05$ in the univariate analysis were entered as candidates in the regression model. A multiple linear regression with the general linear model (GLM) procedure using the enter method was conducted, and variables that remained statistically significant ($P < 0.05$) or were considered clinically relevant were retained in the final model. The final model included APGAR, SSRS, Complication, and Age. Disease stage, postoperative time, self-care ability, and other variables were excluded because they were not significantly associated with SDSS after adjusting for family functioning and social support. The pro-rated SDSS score was used as the dependent variable. Multicollinearity was assessed with the Variance Inflation Factor (VIF), with all values below 10 in the final model. Regression assumptions were evaluated before interpreting the model. Residual normality was examined using P-P plots, homoscedasticity was evaluated via scatterplots of standardized residuals versus predicted values, and influential observations were screened using Cook's distance (values > 1.0 considered potentially influential). No major violations of regression assumptions were identified; all Cook's distance values were below 1.0, indicating no influential cases. Categories with very few participants (e.g., Student, n = 2; Other insurance, n = 2) were retained in descriptive analyses but should be interpreted with caution.

2.7 Mediation effect analysis

The mediation model was estimated using data from all 297 participants. AMOS 30.0 was used to examine the mediating effect of social support on the association between family functioning and social functioning deficits. In the model, family functioning was defined as the independent variable (X), social support as the mediating variable (M), and social functioning deficits (SDSS pro-rated) as the dependent variable (Y). To adjust for potential confounding, age, gender, education, income, disease stage, postoperative time, stoma type, and postoperative complications were entered as covariates. These variables were selected according to theoretical considerations and prior evidence indicating that they might confound the relationships among family functioning, social support, and social functioning. Variables that overlap conceptually with the outcome (e.g., self-care ability, return-to-work status, occupation) were not included to avoid over-adjustment. Model parameters were estimated using the maximum likelihood method. The model had 66 free parameters and 66 distinct sample moments, yielding 0 degrees of freedom (saturated model). Therefore, overall fit indices could not be applied; path coefficients and bootstrap confidence intervals are reported. Bootstrap resampling (5, 000 replicates) was used to test the significance of the mediating effect, and mediation was considered significant when the 95% confidence interval did not include 0 (38). Categories with very few participants (e.g., Student, n = 2; Other insurance, n = 2) were retained in the mediation model but should be interpreted with caution.

2.8 Item-level discriminant validity and sensitivity analyses

To evaluate discriminant validity at the item level, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted using the 21 items applicable to all participants (APGAR: 5 items; SSRS: 9 items after excluding SSRS2 due to zero variance; SDSS: 7 common items). EFA used principal component analysis with varimax rotation. CFA was performed in AMOS 30.0 with three correlated latent factors (APGAR, SSRS, and SDSS_Common) using maximum likelihood estimation. Model fit was assessed using χ^2/df, CFI, TLI, RMSEA, and SRMR. Because the CFA covariance matrix was not positive definite, fit indices were interpreted cautiously.

A sensitivity mediation analysis was then conducted excluding the SSRS item assessing support from family members (SSRS5) and the SDSS item assessing family life (SDSS7), which are the items most conceptually overlapping with the APGAR. The mediation

model was re-estimated using AMOS with 5, 000 bootstrap resamples and bias-corrected 95% confidence intervals. The indirect, direct, and total effects were compared with the primary model.

3 Results

3.1 General demographic characteristics of the sample

A total of 297 patients with colorectal cancer following stoma creation were enrolled, including 187 males (63.0%) and 110 females (37.0%); 54 patients were aged 18–49 years (18.2%), 123 were aged 50–64 years (41.4%), and 120 were aged ≥65 years (40.4%). Of the participants, 261 were married (87.9%), and 174 lived in urban areas (58.6%). Stage III disease was most common (41.1%), and 57 underwent permanent stoma creation (19.2%). Additional sample characteristics are presented in Table 1.

3.2 Scale scores and reliability

Scores from the three scales are summarized in Table 2. The total SDSS score (pro-rated) was 6.43 ± 2.774 (actual range: 1–15 points), with higher scores reflecting greater social functioning deficits. The total APGAR score was 5.76 ± 1.779, suggesting a moderate level of impairment in family functioning. The total SSRS score was 38.78 ± 6.218, reflecting an intermediate level of social support.

The reliability analysis results (Table 3) showed Cronbach's α coefficients of 0.752, 0.731, and 0.799 for the three scales, respectively—all exceeding 0.70, indicating acceptable internal consistency of each scale in the study sample.

3.3 Univariate analysis of social functioning in patients with different characteristics

Normality was assessed using the Shapiro–Wilk test on the measurement data; the results showed that the total SDSS (pro-rated), APGAR, and SSRS scores were not normally distributed ($P < 0.05$) (Table 4); therefore, nonparametric tests were applied in all subsequent between-group comparisons.

According to the univariate analysis (Table 5A), place of residence (U = 7071.500, P < 0.001) and postoperative complications (U = 2420.500, P < 0.001) were significantly associated with SDSS, whereas gender (U = 10128.500, P = 0.826), stoma type (U = 5938.500, P = 0.121), and chemotherapy and radiotherapy (U = 7911.000, P = 0.388) were not. According to the univariate analysis (Table 5B), marital status (H = 21.327, P < 0.001), education level (H = 27.499, P < 0.001), type of occupation (H = 51.464, P < 0.001), main postoperative caregiver (H = 16.615, P = 0.001), monthly per capita household income (H = 76.201, P < 0.001), return-to-work status (H = 20.863, P < 0.001), healthcare payment method (H = 28.169, P < 0.001), disease stage (H = 22.370, P < 0.001), and self-care ability (H = 28.458, P < 0.001) were significantly associated with SDSS. In contrast, no significant associations were observed for age (H = 4.877, P = 0.087), number of children (H = 4.889, P = 0.180), or postoperative time (H = 5.841, P = 0.054).

3.4 Correlation analysis of all scales

Spearman correlation analysis showed (Table 6) that SDSS scores showed significant negative correlations with APGAR scores (r_s = -0.931, P < 0.001) and SSRS scores (r_s= -0.923, P < 0.001), while APGAR scores were significantly positively correlated with SSRS scores (r_s = 0.889, $P < 0.001$). These findings indicate that CRC patients with better family functioning and greater social support generally report less severe social functioning deficits.

3.5 Multiple linear regression analysis of factors influencing social functioning deficits

Potential confounders were accounted for by entering the SDSS (pro-rated) score as the dependent variable. Variables that were significant in univariate analysis were entered as candidates, and a multiple linear regression through the general linear model (GLM) procedure with the enter method was conducted. The final model included APGAR, SSRS, Complication, and Age. As presented in Table 7, the overall regression model was statistically significant (F = 629.201, P < 0.001). The adjusted R^2 was 0.914, showing that the included independent variables explained 91.4% of the variation in total SDSS scores.

Regression analysis showed that the total APGAR score (B = -0.796, P < 0.001) and total SSRS score (B = -0.205, P < 0.001) were the two main factors associated with lower social functioning deficits among patients with CRC and a stoma: stronger family functioning and greater social support were associated with milder social functioning deficits.

After adjustment for the remaining variables, age remained significantly associated with SDSS (50–64 vs 18–49: B = -0.478, P < 0.001; ≥65 vs 18–49: B = -0.468, P = 0.001). Complication showed a trend toward significance (Yes vs No: B = 0.261, P = 0.074). The full model including all candidate variables is presented in Supplementary Table S1. All VIF values in the final model were below 10, suggesting no substantial multicollinearity.

The mediation model (section 3.6) incorporated additional covariates to account for potential confounding.

3.6 Mediation effect analysis of social support

3.6.1 Model fitting evaluation

A mediation model was specified in which family functioning was the independent variable, social support as the mediating variable, and social functioning deficits (SDSS pro-rated) as the dependent variable. The specified model was saturated (df = 0), so overall fit indices were not applicable; path coefficients and bootstrap confidence intervals are reported. Age, gender, education, income, disease stage, postoperative time, stoma type, and postoperative complications were included as covariates to account for potential confounding.

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TABLE 1 Sociodemographic and disease-related characteristics of patients undergoing colorectal cancer surgery with stoma formation.

Variable	Grouping	Frequency (n)	Percent (%)
Age	18–49	54	18.2
	50–64	123	41.4
	≥65	120	40.4
Sex	Male	187	63.0
	Female	110	37.0
Residence	Town	174	58.6
	Village	123	41.4
Marital	Unmarried	16	5.4
	Married	261	87.9
	Divorced	11	3.7
	Widowed	9	3.0
Education	Primary school or below	85	28.6
	Junior high school	105	35.4
	Senior high school or secondary vocational school	48	16.2
	College diploma	45	15.2
	Bachelor's degree or above	14	4.7
Occupation	Farmer	102	34.3
	Worker	39	13.1
	Student	2	0.7
	Public institution	44	14.8
	Individual technician	57	19.2
	Self-employed	26	8.8
	Freelancer	27	9.1
Children	0	21	7.1
	1	49	16.5
	2	130	43.8
	≥3	97	32.7
Primary caregiver	Spouse	115	38.7
	Parents	21	7.1
	Children	145	48.8
	Other	16	5.4
Household monthly income	<3000 ¥	11	3.7
	3000-5000 ¥	178	59.9
	>5000 ¥	108	36.4
Return-to-work status	Back at work	132	44.4
	Not back at work	100	33.7
	Retired	65	21.9
Medical insurance type	Self-paid	12	4.0
	Urban and rural resident medical insurance	190	64.0
	Urban employee medical insurance	93	31.3
	Other	2	0.7
Disease stage	I	28	9.4
	II	80	26.9
	III	122	41.1
	IV	67	22.6
Postoperative time	1–3 months	131	44.1
	4–6 months	72	24.2
	>6 months	94	31.6
Chemotherapy and radiotherapy	No	77	25.9
	Yes	220	74.1
Stoma type	Temporary stoma	240	80.8
	Permanent stoma	57	19.2
Self-care ability	Completely dependent on others	139	46.8
	Partially assisted	100	33.7
	Completely self-care	58	19.5
Postoperative complications	No	253	85.2
	Yes	44	14.8

CNY, 1 ¥ ≈ 0.15 $.

3.6.2 Path analysis

Figure 1 presents the path analysis results. Family functioning showed a statistically significant positive effect on social support (β = 0.836, P < 0.001), whereas social support was significantly negatively associated with social functioning deficits (β = -0.421, P < 0.001). A significant direct inverse association of family functioning on social functioning deficits was also identified (β = -0.529, P < 0.001).

3.6.3 Mediation effect test

Bootstrap analysis with 5, 000 resamples (Table 8) indicated that the indirect effect of family functioning on social functioning deficits through social support was -0.352 (standardized; 95% CI: -0.422 to -0.284); because the confidence interval did not include 0, the indirect effect was statistically significant. This indirect effect accounted for 40.0% of the total effect, indicating a statistically significant indirect association, although cautious interpretation is warranted given the substantial measurement overlap.

TABLE 2 Scores obtained using different scales for patients with colorectal cancer who have undergone ostomy surgery.

Scale	Number of entries	Theoretical scope	Actual range	Mean and standard deviation
SDSS	10	0–20	1–15	6.43 ± 2.774
APGAR	5	0–10	1–9	5.76 ± 1.779
SSRS	10	12–66	19–56	38.78 ± 6.218

SDSS = pro-rated score (higher scores reflect greater social functioning deficits). The pro-rated score was calculated as (sum of applicable items/number of applicable items) × 10. APGAR, Family APGAR Index; SSRS, Social Support Rating Scale.

TABLE 3 Reliability analysis for all scales.

Scale	Cronbach's α	Number of entries
SDSS	0.752	10
APGAR	0.731	5
SSRS	0.799	10

SDSS reliability was estimated using 122 complete cases because some items were not applicable (occupation, marital, and parental items).

Sensitivity analysis using only the seven items applicable to all participants (excluding occupation, marital, and parental items) produced comparable findings. The indirect effect through social support was -0.362 (standardized; 95% CI: -0.463 to -0.269), accounting for 45.1% of the total effect. APGAR and SSRS continued to be significantly associated with SDSS_Common (both $P < 0.001$). These findings support the robustness of the primary mediation effect. The full sensitivity analysis is provided in Supplementary Table S2.

3.7 Item-level discriminant validity and sensitivity analysis

EFA (KMO = 0.908; Bartlett's $\chi^2 = 3188.869$, df = 210, $p < .001$) showed a dominant first component (43.4% of 55.6% total variance) and nine items with cross-loadings > 0.40; no clear three-factor structure emerged. The three-factor CFA ($\chi^2 = 578.934$, df = 186, $p < .001$; $\chi^2/df = 3.113$; CFI = 0.872; TLI = 0.855; RMSEA = 0.084; SRMR = 0.034; loadings 0.373–0.805) yielded latent correlations exceeding 1 (APGAR ↔ SSRS = 1.123; SSRS ↔ SDSS = −1.115; APGAR ↔ SDSS = −1.269) and a non-positive definite covariance matrix (Heywood case). Merging APGAR and SSRS or removing cross-loading items also produced correlations > 1 (−1.133 and −1.008). These findings indicate that the three scales did not demonstrate discriminant validity at the item level.

In a sensitivity mediation analysis excluding overlapping family-related items (SSRS5 and SDSS7), the indirect effect remained significant (standardized β = −0.254, BC 95% CI −0.376 to −0.138), representing 34.7% of the total effect (β = −0.731), compared with 40.0% in the primary model. The direct effect was β = −0.477 (BC 95% CI −0.609 to −0.336). Thus, the indirect association was not solely driven by overlapping content, although cautious interpretation is warranted. Researcher assistance was mainly provided to older adults for visual decline, limited literacy or item comprehension, and postoperative fatigue; because assistance was not recorded as a separate variable, assisted and independent completions could not be compared. However, age was included as a covariate in the mediation model, which partially controls for the age-related assistance effect. The full results are provided in Supplementary Table S3.

4 Discussion

A mediation model was used in the present study to evaluate the pathway linking family functioning, social support, and social functioning deficits in CRC stoma patients. Social functioning deficits were generally mild (SDSS pro-rated: 6.43 ± 2.774), while family functioning and social support were identified as two factors associated with lower social functioning deficits. The regression model explained 91.4% of the variance (adjusted $R^2 = 0.914$), while the mediation model yielded R^2 values of 0.814 for SSRS and 0.910 for SDSS. The high R^2 value (0.910) indicates the strong theoretical and empirical relationship among family functioning, social support, and social functioning outcomes, and is consistent with the high correlation coefficient found between APGAR and SSRS (r_s=0.889). This pattern is consistent with theory because social support may serve as one mechanism through which family functioning is associated with social functioning. The indirect effect accounted for 40.0% of the total effect, although this statistical association should be interpreted with caution given the substantial measurement overlap. Family functioning and social support serve as the coping mechanisms in the control process whereas CRC diagnosis and stoma creation represent the

TABLE 4 Normality testing for all scale scores.

Scale	KS statistic	KS significance	SW statistic	SW significance
SDSS	0.096	<0.001	0.960	<0.001
APGAR	0.170	<0.001	0.945	<0.001
SSRS	0.076	<0.001	0.980	<0.001

KS, Kolmogorov-Smirnov with Lilliefors correction; SW, Shapiro-Wilk. All tests were conducted using the pro-rated SDSS score. N = 297.

TABLE 5A Differences in SDSS scores across binary categorical variables (Mann–Whitney U test).

Variable	Grouping	n	M (P25, P75)	U	Z	*P*
Sex	Male	187	6.0 (4.0, 8.0)	10128.500	-0.219	0.826
	Female	110	6.0 (4.4, 8.0)			
Residence	Town	174	5.56 (3.75, 7.78)	7071.500	-4.987	<0.001
	Village	123	6.67 (5.56, 9.00)			
Stoma type	Temporary stoma	240	6.67 (4.44, 8.00)	5938.500	-1.549	0.121
	Permanent stoma	57	5.00 (3.54, 8.75)			
Postoperative complications	No	253	5.56 (4.00, 7.78)	2420.500	-5.993	<0.001
	Yes	44	8.94 (6.75, 11.11)			
Chemotherapy and radiotherapy	No	77	6.67 (4.72, 8.38)	7911.000	-0.863	0.388
	Yes	220	5.56 (4.00, 8.00)			

M, median; P25 and P75, 25th and 75th percentiles. SDSS = pro-rated score (higher = greater social functioning deficits). Mann–Whitney U test.

input stimuli in Roy's Adaptation Model. Social functioning status represents the adaptation outcome. Better family functioning may strengthen patient adaptation resources in terms of their access to social support (β = 0.836), which in turn is associated with a better social functioning outcome (β = -0.421). The pathway from the control process to the adaptation outcome is consistent with the interdependent adaptation component of Roy's model and may inform future hypothesis-driven research, although the cross-sectional design precludes any inference about intervention benefits. In Roy's model, both family functioning and social support belong to the control process. The present study specified family functioning as preceding social support because the family is typically the most

TABLE 5B Differences in SDSS scores across multilevel categorical variables (Kruskal–Wallis H test).

Variable	H	df	*P*	*Post-hoc* (Bonferroni-corrected)
Age	4.877	2	0.087	—
Marital	21.327	3	<0.001	Married < Widowed (Adj. P < 0.001); Unmarried < Widowed (Adj. P = 0.022)
Education	27.499	4	<0.001	College diploma < Primary school or below (Adj. P < 0.001); Bachelor's or above < Primary school or below (Adj. P = 0.002)
Occupation	51.464	6	<0.001	Public institution < Farmer (Adj. P < 0.001); Public institution < Worker (Adj. P < 0.001); Public institution < Freelancer (Adj. P = 0.019); Self-employed < Farmer (Adj. P = 0.001); Self-employed < Worker (Adj. P < 0.001); Individual technician < Worker (Adj. P = 0.038)
Children	4.889	3	0.180	—
Primary caregiver	16.615	3	<0.001	Spouse < Parents (Adj. P = 0.004); Spouse < Children (Adj. P = 0.015)
Household monthly income	76.201	2	<0.001	>5000 ¥ < 3000–5000 ¥ < <3000 ¥ (all Adj. P ≤ 0.001)
Return-to-work status	20.863	2	<0.001	Returned to work < Not returned (Adj. P < 0.001); Retired < Not returned (Adj. P = 0.001)
Medical insurance type	28.169	3	<0.001	Urban employee < Urban/rural resident (Adj. P < 0.001); Urban employee < Self-paid (Adj. P = 0.001)
Disease stage	22.370	3	<0.001	Stage I < Stage II (Adj. P = 0.004); Stage I < Stage III (Adj. P = 0.004); Stage I < Stage IV (Adj. P < 0.001)
Postoperative time	5.841	2	0.054	—
Self-care ability	28.458	2	<0.001	Completely self-care < Partially assisted (Adj. P < 0.001); Completely self-care < Completely dependent (Adj. P < 0.001)

H = Kruskal-Wallis test statistic; *Post hoc* comparisons were adjusted with the Bonferroni correction. SDSS = pro-rated score (higher = greater social functioning deficits). "—" indicates no significant *post-hoc* comparison. For medical insurance type, the "Other" group (n = 2) was included in the Kruskal-Wallis test but not in *post-hoc* comparisons due to insufficient sample size.

TABLE 6 Spearman's correlations between SDSS scores and other scale scores.

Variable	SDSS	APGAR	SSRS
SDSS	1.000	-0.931***	-0.923***
APGAR	-0.931***	1.000	0.889***
SSRS	-0.923***	0.889***	1.000

***P < 0.001. SDSS, pro-rated score (higher = greater social functioning deficits).

proximal and enduring source of support for patients with a stoma, and previous qualitative work has identified family responses as shaping patients' broader social engagement. However, because the design is cross-sectional, this ordering should be regarded as a theoretically informed specification rather than an empirically established temporal sequence; reverse or reciprocal relationships cannot be excluded.

The high correlation between APGAR and SSRS scores (r = 0.889) requires cautious interpretation. This close relationship may reflect conceptual overlap between family functioning and social support, as the family frequently serves as a primary source of emotional and instrumental support (29). Previous studies have similarly reported strong correlations between these constructs (29), supporting their theoretical relatedness. Nevertheless, the separate roles of family functioning and social support in predicting social functioning deficits are suggested by several findings. First, both variables remained statistically significant in the regression model, with VIF values below 10. Second, the mediation model showed a statistically significant indirect association between family functioning and social functioning deficits. Third, sensitivity analyses confirmed the robustness of these findings. However, item-level EFA and CFA revealed that the three scales lack discriminant validity, with latent correlations exceeding 1 in all attempted models. This suggests that the measures may capture a single underlying construct rather than distinct dimensions. Nevertheless, a sensitivity analysis excluding overlapping family-related content (SSRS5 and SDSS7) showed that the indirect effect remained significant (β = -0.254, BC 95% CI: -0.376 to -0.138), indicating that the indirect association was not solely driven by overlapping content. The mediation effect should, however, be interpreted as a statistical association rather than a distinct causal mechanism, given the substantial measurement overlap. Future studies may use item-level measurement models to better differentiate these constructs and clarify their unique contributions.

Social support was not only associated with the indirect pathway between family functioning and social functioning deficits, but was also independently associated with the outcome. The standardized direct effect of family functioning on social functioning deficits (β = -0.529) was greater than that of social support (β = -0.421), indicating that family functioning may show a stronger direct association with social functioning outcomes, while social support was also independently associated with the outcome. Karadede and Rizalar (24) reported reduced anxiety when patients received more information support, while Liao et al. (39) showed that social support was directly and multifaceted associated with social functioning in patients with colorectal cancer stoma.

In addition, family functioning exerted a direct effect (β = -0.529) as well as an indirect effect (accounting for 40.0% of the total effect), suggesting the presence of two pathways. This finding is consistent with evidence from previous studies: family members, particularly children, spouses, and siblings, provide an important source of support for patients with an intestinal stoma during the medical visit and at home (40). Xin, Viroj and Glangkarn (29) confirmed that family functioning might significantly moderate the indirect effect of psychological distress on quality of life. Liao et al. (39) also found that family resilience mediated the relationship between impaired social functioning and quality of life in patients with an intestinal stoma. Furthermore, He et al. (41) reported that favorable family functioning was significantly associated with a lower probability of falling into the "no social isolation and no loneliness" group. In light of these findings, the present study provides evidence of a statistical indirect association between family functioning and social functioning deficits. However, the indirect association accounted for 40.0% of the total effect rather than 100%, indicating that family functioning could also be directly associated with social functioning without going through social support. This direct association may reflect family caregiving, emotional reassurance, and encouragement during rehabilitation, further emphasizing the important role of family functioning in the rehabilitation of CRC stoma patients.

In the adjusted regression analysis, age remained significantly associated with social functioning deficits. Patients aged 50–64 years and ≥65 years had significantly lower SDSS scores than those aged 18–49 years, indicating that older patients tended to report milder social functioning deficits. This agrees with previous findings that older patients with stomas report better psychosocial functioning and quality of life than younger patients (42, 43). Younger adults

TABLE 7 Multiple linear regression of factors associated with social functioning deficits (dependent variable: SDSS, pro-rated).

Variable	B	SE	β	t	*P*	95% CI
(Constant)	19.116	0.391	—	48.830	<0.001	18.345–19.886
APGAR_Total	-0.796	0.060	-0.511	-13.236	<0.001	-0.915–0.678
SSRS_Total	-0.205	0.017	-0.460	-11.785	<0.001	-0.239–0.171
Postoperative complications (Yes vs No)	0.261	0.146	—	1.795	0.074	-0.025–0.548
Age (50–64 vs 18–49)	-0.478	0.133	—	-3.585	<0.001	-0.741–0.216
Age (≥65 vs 18–49)	-0.468	0.135	—	-3.467	0.001	-0.734–0.202

Dependent variable: SDSS_Prop (pro-rated). β = standardized beta. For categorical variables, standardized beta coefficients are not reported because dummy variable standard deviations are not meaningful. Reference groups: Postoperative complications (No), Age (18–49). Regression model: R^2 = 0.915, Adjusted R^2 = 0.914, F = 629.201, P < 0.001.

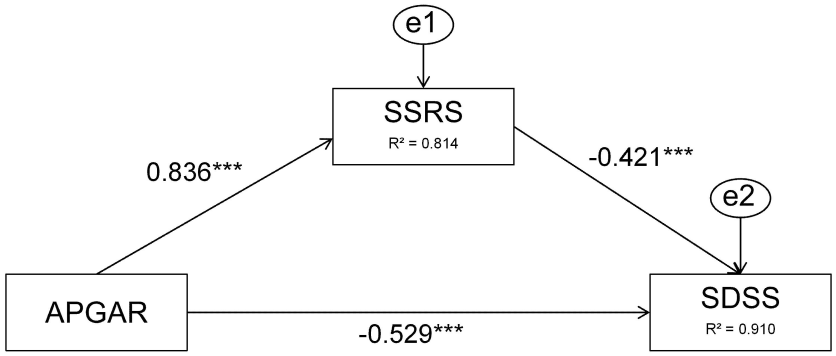


FIGURE 1
Mediation model showing social support as a mediator between family functioning and social functioning deficits. Standardized path coefficients are presented. APGAR, Family APGAR Index; SSRS, Social Support Rating Scale; SDSS, Social Dysfunction Screening Scale (pro-rated). ***P < 0.001. Covariates (age, gender, education, income, disease stage, postoperative time, stoma type, and postoperative complications) were included in the model but are not shown for clarity. The indirect effect via social support was -0.352 (standardized; 95% CI: -0.422 to -0.284), accounting for 40.0% of the total effect. The direct effect of family functioning on social functioning deficits was -0.529 (P < 0.001). Mediation model R^2: SSRS = 0.814; R^2 for SDSS = 0.910.

may experience greater disruption to career development, social roles, and family responsibilities, making the impact of a stoma more pronounced. In contrast, older patients may have lower social role expectations and more established coping patterns, which may lessen the psychosocial impact of stoma creation (44).

Postoperative complications showed a trend toward significance (P = 0.074), with patients experiencing complications reporting higher SDSS scores. Qualitative studies suggest that stoma-related complications, including peristomal skin irritation, leakage, and difficulty managing supplies, can contribute to anxiety, reluctance to go out in public, and social isolation (45). Physical complications may limit patients' mobility and daily activities, further restricting social participation (46). Although this association was not statistically significant at the conventional threshold, the trend suggests that preventing and managing postoperative complications could be clinically relevant for improving social outcomes in this population.

4.1 Limitations

Several limitations of this study should be acknowledged. First, the cross-sectional design precludes establishing causal relationships or temporal ordering; the observed indirect effect represents a statistical association rather than a proven causal pathway. Second, convenience sampling from a single hospital may restrict generalizability; additional multicenter studies are warranted. Third, anxiety, depression, and coping styles were not assessed and may confound the associations. Fourth, the SDSS "occupation, " "marital function, " and "parental function" items were not applicable to some participants (e.g., retired, unemployed, students, unmarried, or childless); although a pro-rated score was used (Cronbach's α = 0.752; 122 complete cases), its validity across the full cohort requires confirmation. Sensitivity analysis restricted to universally applicable items yielded consistent results, although the direct effect decreased slightly, suggesting some direct effect may be carried by occupation, marital, or parental items. Fifth, item-level EFA and CFA revealed substantial overlap among the three scales, with latent correlations exceeding 1 and a non-positive definite covariance matrix, suggesting they may capture a single underlying construct. A sensitivity analysis excluding overlapping family-related items (SSRS5 and SDSS7) showed that the indirect effect persisted (34.7% vs 40.0% in the primary model), but the mediation effect should still be interpreted with caution. Sixth, researcher assistance, mainly for older adults with visual, literacy, or fatigue-related difficulties, was not systematically recorded; therefore, its influence could not be directly assessed, although age was included as a covariate. Seventh, the cohort combined different postoperative stages and stoma types, and some categories contained very few participants (e.g., Student, n = 2; Other insurance, n = 2); these subgroups represent different postoperative contexts rather than successive observations of the same recovery process, and future research should evaluate consistency across these subgroups. Finally, the mediation model was saturated (df = 0), so fit indices were not applicable; all VIF values in the final regression model were below 10. Longitudinal or intervention studies are needed to validate these findings.

TABLE 8 **Decomposition of the indirect association of social support between family functioning and social functioning deficits.**

Effect type	Non-standardized estimate	Standardized estimate	Bootstrap 95% CI (BC)	Proportion of total effect
Total effect	-1.254	-0.881	[-1.322, -1.185]	100%
Direct effect	-0.752	-0.529	[-0.866, -0.641]	60.0%
Indirect effect	-0.501	-0.352	Non-standardized: [-0.602, -0.406] Standardized: [-0.422, -0.284]	40.0%

BC, bias-corrected; Bootstrap resampling = 5, 000. Covariates were: age, gender, education, income, disease stage, postoperative time, stoma type, and postoperative complications. SDSS = pro-rated score (higher scores = greater social functioning deficits). The 95% CI for the indirect effect did not include 0, indicating a statistically significant indirect association.

5 Conclusion

The present study found that social support was associated with the relationship between family functioning and social functioning deficits among patients with colorectal cancer (CRC) stoma. The indirect effect was -0.352 (95% CI: -0.422 to -0.284) and represented 40.0% of the total effect. Thus, family functioning appears to be associated with patients' social functioning directly and indirectly through greater social support. However, given the substantial measurement overlap and the cross-sectional design, these associations should be interpreted with caution. Longitudinal or intervention studies are needed to examine potential causal relationships and to determine whether interventions targeting family functioning and social support would improve social functioning in this population.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Clinical Research Ethics Committee of Guangdong Medical University Affiliated Hospital(Approval No.: KT2026-042-01). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JL: Conceptualization, Formal analysis, Methodology, Writing – original draft, Data curation, Project administration, Visualization, Investigation. LL: Formal analysis, Data curation, Writing – review & editing, Investigation. RL: Data curation, Writing – review & editing, Investigation. LW: Writing – review & editing. HX: Resources, Conceptualization, Project administration, Writing – review & editing, Supervision.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fonc.2026.1983942/full#supplementary-material

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