IJEBM International Journal of Evidence-Based Medicine

International Journal of Evidence-Based Medicine
(eISSN 3083-1776)

Australasia Publishing Group

Original Article

A Multistage Multidisciplinary Rehabilitation Program Improves Postoperative Recovery, Nutritional Status, and Parental Psychosocial Outcomes in Neonates with Congenital Gastrointestinal Malformations: A Prospective Comparative Cohort Study

Jamshid Shamsiev[1], Sukhrob Zainiev[1], Jasur Rizayev[1]

[1]*Specialized Pediatric Surgical Clinic, Samarkand State Medical University, Samarkand, Uzbekistan*

Received: Jul 06, 2026
Accepted: Aug 26, 2026

Corresponding author's email:
shamsievja@gmail.com

Citation: Shamsiev J, Zainiev S, Rizayev J. A Multistage Multidisciplinary Rehabilitation Program Improves Postoperative Recovery, Nutritional Status, and Parental Psychosocial Outcomes in Neonates with Congenital Gastrointestinal Malformations: A Prospective Comparative Cohort Study. International Journal of Evidence-Based Medicine. 2026;1(3):jebm012.
https://doi.org/10.63946/jebm/19222

ABSTRACT

Congenital malformations of the gastrointestinal tract are a leading cause of neonatal surgical mortality and long-term disability, and outcomes remain markedly worse in low- and middle-income settings than in high-income countries, in part because of fragmented postoperative follow-up. We conducted a combined retrospective-prospective cohort study in the Samarkand region of Uzbekistan (2021–2024) to characterize the epidemiology and risk-factor profile of congenital gastrointestinal malformations and to evaluate a purpose-built, multistage, multidisciplinary rehabilitation program for infants after corrective surgery. Of 283 surgically treated neonates, 163 received the multistage rehabilitation program (surgical, nutritional, physiotherapeutic, psychosocial and telemedicine components) and 120 received standard postoperative care. The rehabilitation program was associated with a shorter hospital stay (20.8 ± 3.2 vs 28.1 ± 3.5 days, $p<0.001$), a lower rate of postoperative complications (9.8% vs 25.7%, $p<0.01$), fewer unplanned readmissions at 6 months (11.0% vs 31.5%, $p<0.01$), and greater weight gain and serum protein/albumin recovery at 6 months (all $p<0.01$). Composite gastrointestinal functional recovery at 6 months was achieved in 90.2% of the program group versus 64.1% of the comparison group ($p<0.001$). Parental anxiety (State-Trait Anxiety Inventory) fell further in the program group (48.2±6.1 to 34.5±4.8) than in controls (47.8±6.3 to 42.9±5.2, $p<0.001$), and confidence in caregiving (visual analogue scale) improved correspondingly. A multivariable model incorporating birth weight, number of malformations and timing of nutritional rehabilitation predicted adverse outcome with 87.4% accuracy. These findings support multistage, family-centered, telemedicine-enabled rehabilitation as an effective and scalable strategy for improving postoperative outcomes after neonatal gastrointestinal surgery, particularly in resource-constrained regional health systems.

Keywords: Congenital Gastrointestinal Malformations; Neonatal Surgery; Postoperative Rehabilitation; Multidisciplinary Care; Gastroschisis; Hirschsprung Disease; Anorectal Malformation; Telemedicine

Introduction

Congenital anomalies are the fifth leading cause of death in children under five years of age worldwide, accounting for an estimated half a million deaths annually, with 97% of these deaths occurring in low- and middle-income countries (Wright et al., 2019). Gastrointestinal malformations — including oesophageal and intestinal atresia, gastroschisis, Hirschsprung disease and anorectal malformations — constitute a substantial share of this burden and are among the anomalies most amenable to survival gains through timely surgical intervention (Wright et al., 2019). Multicentre data spanning 74 countries show that mortality after surgery for these conditions in low-income countries is several-fold higher than in high-income countries, a gap driven less by operative technique than by deficiencies in perioperative and postoperative systems of care (GlobalPaedSurg Research Collaboration, 2021).

In Uzbekistan, congenital malformations are the leading identified cause of neonatal death, and gastrointestinal anomalies requiring specialized surgical and postoperative care remain a source of disproportionate mortality and disability, aggravated by the limited number of centres with dedicated neonatal surgical expertise. Survival after corrective surgery, however, is only the first milestone: infants who survive gastroschisis, intestinal atresia, Hirschsprung disease or anorectal malformation frequently experience prolonged disturbances of gastrointestinal motility, feeding intolerance, growth failure and neurodevelopmental delay, and their families report high levels of psychological distress that itself predicts poorer clinical trajectories (Govindaswamy et al., 2020). International evidence from pediatric intestinal rehabilitation programs demonstrates that coordinated, multidisciplinary care markedly improves survival and reduces complications in children with intestinal failure and short bowel syndrome (Modi et al., 2008), and consensus perioperative guidelines now recommend structured, enhanced-recovery pathways for neonatal intestinal surgery (ERAS® Society, 2020). Yet such organized rehabilitation models remain largely undescribed outside a small number of specialized referral centres, and their applicability to a regional health system in a middle-income country has not been established.

We hypothesized that a locally developed, multistage rehabilitation program — combining early individualized nutritional support, physiotherapy, structured parental education, psychosocial support and telemedicine-enabled follow-up — would improve clinical, nutritional and psychosocial outcomes after surgery for congenital gastrointestinal malformations, relative to standard postoperative care, in a regional referral system in Central Asia. We further aimed to characterize the regional epidemiology and risk-factor profile of these malformations, and to develop a predictive model for adverse outcome that could support risk-stratified referral and rehabilitation planning.

Materials and Methods

Study design and setting

We conducted a combined retrospective–prospective cohort study at the Specialized Pediatric Surgical Clinic (Clinic No. 2) of Samarkand State Medical University, the Republican Perinatal Center, and the Regional Children's Multidisciplinary Medical Center, Samarkand Region, Uzbekistan, covering the period 2021–2024. The retrospective component (2021–2023) comprised structured review of maternal and neonatal medical records; the prospective component followed newly enrolled mother–infant dyads with contemporaneous data collection, laboratory monitoring and structured follow-up through the rehabilitation program described below. The study was designed in four sequential stages: (i) cohort formation and risk-factor characterization, (ii) surgical treatment and early postoperative monitoring, (iii) implementation and evaluation of the rehabilitation program, and (iv) predictive modelling of adverse outcome.

Participants

Consecutive neonates diagnosed with a congenital gastrointestinal malformation (oesophageal or intestinal atresia/stenosis, Hirschsprung disease, gastroschisis, or anorectal malformation) and their mothers were eligible. Inclusion criteria were: confirmed diagnosis of a congenital gastrointestinal malformation; birth in the Samarkand region between 2021 and 2024; complete maternal and neonatal medical records including pregnancy and delivery history; and informed consent from parents or legal guardians. Exclusion criteria were: multiple malformations incompatible with survival; histologically confirmed severe intrauterine infection; incomplete medical documentation; and parental refusal to participate.

A total of 285 neonates with congenital gastrointestinal malformations were identified over the study period, corresponding to a regional incidence of 1.8 cases per 1,000 live births. A malformation-free comparison group of 200 neonates, matched for infant sex, maternal age and gestational age, was assembled to characterize antenatal risk factors (Section 3.1). Among

the 283 malformation cases with complete surgical and follow-up data, 263 subsequently entered the multistage postoperative rehabilitation program described in Section 2.3; for the primary comparative efficacy analysis (Section 3.3–3.5), 163 infants who received the full multistage program (program group) were compared with 120 infants, drawn from the same clinical population and time period, who received standard postoperative care and conventional rehabilitation elements without the multistage program (comparison group). Group assignment reflected the sequential, region-wide rollout of the program and clinical/logistic factors governing accessibility (e.g., distance from the rehabilitation centre) rather than randomization; this non-randomized design is addressed as a limitation in the Discussion. Participant flow through enrollment, allocation and analysis is summarized in Figure 1.

Figure 1. Participant flow through enrollment, allocation, and analysis

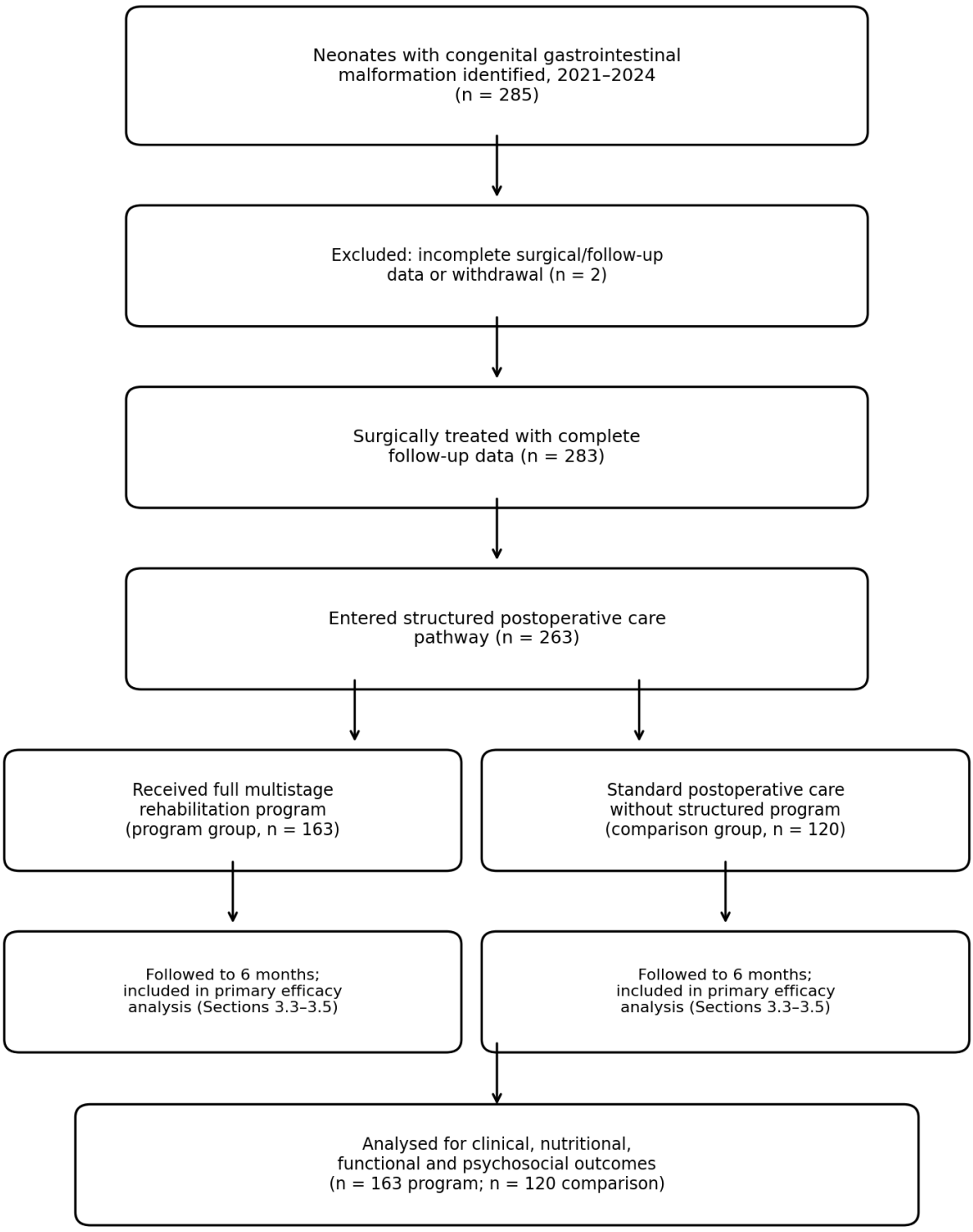

Figure 1. Participant flow through enrollment, allocation, and analysis.

Formal statistical comparison of baseline birth weight, gestational age, and malformation-type distribution between the program group (n=163) and the comparison group (n=120) was not tabulated for this cohort; this is noted as a limitation in the Discussion, alongside the non-randomized allocation described above.

The multistage rehabilitation program

The program was delivered through a dedicated rehabilitation centre staffed by a pediatric surgeon, pediatrician, gastroenterologist, dietitian/nutritionist, physiotherapist, psychologist and social worker, working as a coordinated multidisciplinary team. Rehabilitation began immediately after surgery, with an individualized recovery plan established prior to discharge and covering: (i) a stepwise, individualized enteral feeding protocol incorporating gradual introduction of oral/enteral intake, caloric titration and, where indicated, prebiotic-supplemented therapeutic formula; (ii) pharmacological and non-pharmacological bowel-function support (enzyme therapy, probiotics, and mild laxatives where indicated) together with parental training in stoma and feeding care; (iii) physiotherapy, therapeutic exercise, massage and sensory stimulation for infants with delayed motor development; (iv) a structured caregiver education curriculum ("Parent School"), comprising four to five thematic 60–90-minute sessions covering disease pathophysiology, feeding technique, stoma care, complication recognition and psychological self-regulation; (v) individual psychological support (art therapy, cognitive-behavioural techniques, breathing and relaxation training) for families showing signs of emotional exhaustion or impaired parent–infant bonding; and (vi) telemedicine-enabled remote consultation, including electronic feeding/stool diaries, for monitoring stoma status, feeding regimen and early complication detection between in-person visits. A rehabilitation coordinator ensured continuity of information transfer between the inpatient, rehabilitation-centre and outpatient stages, and multidisciplinary case conferences were held approximately every two weeks to revise individual care plans. Infants in the comparison group received standard postoperative surgical care and ad hoc outpatient follow-up without access to the multistage multidisciplinary program, dedicated coordinator, parent-education curriculum or telemedicine module.

The enteral feeding component followed a stepwise, individualized formula-introduction schedule with caloric titration and, where indicated, a prebiotic-supplemented therapeutic formula, adjusted at the discretion of the multidisciplinary team according to each infant's tolerance; the physiotherapy component comprised therapeutic exercise, massage, physiotherapy procedures and sensory stimulation, delivered according to individualized recovery plans rather than a fixed session schedule. Because the comparison group received non-protocolized, ad hoc postoperative care by definition, there is no equivalent structured feeding or physiotherapy regimen in that group against which to itemize a direct contrast; this asymmetry is itself part of what distinguishes the two arms of the study.

Data collection and outcome measures

Data were collected using a purpose-built 46-item structured instrument covering demographic, obstetric, clinical, laboratory and socio-economic parameters, and were entered into a standardized electronic case-record system. Maternal variables included age, anaemia, chronic somatic pathology, gestational registration timing, environmental exposures, first-trimester viral infection and socio-economic status. Neonatal variables included birth weight, gestational age, Apgar scores, malformation type and combinations, surgical procedure and timing, and length of hospital stay. Clinical outcome measures included postoperative complications, unplanned readmission, emergency reoperation, and time from discharge to first rehabilitation-centre contact. Nutritional outcomes included body-mass index (BMI), monthly weight gain, and serum total protein and albumin. Gastrointestinal functional recovery was assessed at 1, 3 and 6 months using a composite of motor–evacuator function normalization, regular stool frequency, resolution of vomiting/regurgitation, appetite/feeding tolerance, and normalization of nutritional status. Parental psychosocial status was assessed using the State-Trait Anxiety Inventory (STAI; range 20–80, with scores >45 indicating clinically significant anxiety) and a 0–10 visual analogue scale (VAS) of caregiving confidence, administered before rehabilitation and after approximately 3 months.

Statistical analysis

Normally distributed continuous variables are presented as mean ± standard deviation and were compared using Student's t-test; non-normally distributed variables are presented as median with interquartile range and were compared using the Mann-Whitney U test. Comparisons across more than two groups used one-way ANOVA or the Kruskal-Wallis test as appropriate. Categorical variables were compared using Pearson's $\chi 2$ test or Fisher's exact test for small samples. Normality was assessed with the Shapiro-Wilk test and visual inspection of histograms/Q-Q plots; homogeneity of variance was assessed with Levene's test. Associations between

continuous variables were assessed using Pearson's or Spearman's correlation coefficient as appropriate. Independent predictors of adverse outcome (death or disability) were identified using multivariable logistic regression, with model discrimination assessed by sensitivity, specificity and overall accuracy; a survival analysis (Kaplan-Meier) was used to characterize cumulative outcome probability across risk strata. Statistical significance was set at $p<0.05$, with $p<0.01$ used for the most clinically important comparisons; the Bonferroni correction was applied where multiple comparisons required adjustment. Effect sizes (Cohen's d for continuous outcomes; odds ratio [OR] with 95% confidence interval for categorical outcomes) are reported alongside all statistically significant comparisons in Sections 3.3–3.5 and 3.7 to convey the clinical magnitude of the observed differences in addition to statistical significance.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki (2013). Written informed consent was obtained from all participating mothers, and from parents or legal guardians on behalf of participating neonates; only de-identified clinical data were analysed. Full approval details are provided in the Ethics Statement.

Results

Epidemiology and antenatal risk-factor profile

Congenital gastrointestinal malformations were identified in 285 neonates over the study period, corresponding to a regional birth prevalence of 1.8 per 1,000 live births. Compared with the 200 malformation-free controls, mothers of affected infants had significantly higher rates of anaemia during pregnancy, chronic somatic pathology, late antenatal registration (>20 weeks), adverse environmental exposure, first-trimester viral infection, and low socio-economic status (Table 1); maternal age did not differ significantly between groups.

Table 1. Maternal characteristics in the congenital gastrointestinal malformation group versus malformation-free controls.

Indicator	Malformation group (n=283)	Control group (n=200)	p
Maternal age, years (mean ± SD)	29.4 ± 1.8	27.6 ± 1.5	>0.05
Anaemia during pregnancy, %	41.3	17.5	<0.01
Chronic somatic pathology, %	38.7	21.1	<0.05
Late antenatal registration (>20 wk), %	32.8	14.2	<0.01
Adverse environmental exposure, %	29.5	11.4	<0.01
First-trimester viral infection, %	24.1	10.2	<0.05
Low socio-economic status, %	21.6	9.8	<0.05

The cumulative number of adverse antenatal factors correlated with malformation severity ($r=0.61$, $p<0.01$), and quality of antenatal care correlated inversely with the frequency of neonatal postoperative complications ($r=-0.44$, $p<0.05$).

Predictors of adverse outcome

Three prognostic risk categories were defined empirically according to combinations of malformation type, birth weight and timing of surgical/rehabilitative intervention (Table 2).

Table 2. Prognostic risk categories for congenital gastrointestinal malformation outcomes.

Risk category	Defining features	Mean mortality, %	1-year disability, %
Low	Isolated malformation, birth weight >2500 g, early surgery	5.8	8.1
Intermediate	Combined malformations, hypotrophy, delayed surgery	19.3	27.6
High	Multiple anomalies, birth weight <1500 g, delayed rehabilitation	42.0	58.3

On multivariable logistic regression, independent predictors of mortality were birth weight <2000 g (OR 4.6, 95% CI 2.1–7.8, p<0.01), the presence of multiple malformations (OR 3.9, p<0.01), and delayed initiation of nutritional rehabilitation (OR 2.8, p<0.05). A predictive model combining these variables with Kaplan-Meier survival analysis achieved 87.4% overall accuracy, 89.4% sensitivity and 83.2% specificity for adverse outcome. No internal validation of the model (e.g., split-sample validation or bootstrapping) was performed, a limitation attributable to the constrained sample size of the high-risk subgroup; this is stated explicitly below and in the Discussion.

Clinical effectiveness of the rehabilitation program

Among the 283 surgically treated neonates with complete follow-up, the 163 infants who received the multistage rehabilitation program had a significantly shorter hospital stay, fewer postoperative complications, fewer 6-month readmissions, and better nutritional and biochemical recovery than the 120 infants who received standard care (Table 3).

Table 3. Comparative near-term clinical outcomes: rehabilitation program group versus comparison group.

Outcome	Program group (n=163)	Comparison group (n=120)	p	Effect size
Length of hospital stay, days (mean ± SD)	20.8 ± 3.2	28.1 ± 3.5	<0.001	Cohen's d = 2.19
Postoperative complications, %	9.8	25.7	<0.01	OR 0.31 (95% CI 0.16–0.60)
Readmission within 6 months, %	11.0	31.5	<0.01	OR 0.27 (95% CI 0.14–0.50)
Mean weight gain at 6 months, g	2980 ± 220	2550 ± 200	<0.001	Cohen's d = 2.03
Total serum protein at 1 month, g/L	63.9 ± 3.1	58.6 ± 3.4	<0.01	Cohen's d = 1.64
Serum albumin, g/L	39.8 ± 2.3	35.7 ± 2.5	<0.01	Cohen's d = 1.72

Effect sizes are computed from the reported group means, standard deviations and sample sizes (Cohen's d) or from reconstructed 2×2 tables (odds ratio [OR]); all correspond to large effects by conventional benchmarks (d ≥ 0.8; OR substantially different from 1).

Recovery of gastrointestinal function

Composite gastrointestinal functional recovery — incorporating normalization of motor-evacuator function, regular stool pattern, resolution of vomiting/regurgitation, restored appetite, and normalized nutritional status — was consistently more frequent and occurred earlier in the program group than in the comparison group across all follow-up time points (Table 4).

Table 4. Time course of composite gastrointestinal functional recovery, by individual follow-up month.

Domain *	*Time point** * g	*Program **roup, %** gr	Comparison **oup, %**	p**
Motor-evacuator normalization Motor-evacuator normalization Motor-evacuator normalization	1 month 3 months 6 months	52.1 79.1 91.4	33.3 56.7 65.0	<0.05 <0.01 <0.001
Regular stool pattern Regular stool pattern Regular stool pattern	1 month 3 months 6 months	47.2 76.0 89.0	29.1 54.2 61.7	<0.05 <0.01 <0.001
Resolution of vomiting Resolution of vomiting Resolution of vomiting	1 month 3 months 6 months	58.9 81.0 93.3	41.6 59.2 70.8	<0.05 <0.01 <0.001
Appetite/feeding tolerance Appetite/feeding tolerance Appetite/feeding tolerance	1 month 3 months 6 months	60.1 83.4 94.5	42.5 58.3 68.3	<0.05 <0.01 <0.001
Composite (all criteria) Composite (all criteria) Composite (all criteria)	1 month 3 months 6 months	49.1 77.9 90.2	30.0 55.8 64.1	<0.05 <0.01 <0.001

At 6 months, the composite recovery outcome corresponded to an odds ratio of 5.13 (95% CI 2.71–9.70) favoring the program group.

Nutritional and gastrointestinal-symptom outcomes in the broader program cohort

Among all 263 infants enrolled in the rehabilitation program, 61 (23.2%) presented at intake with moderate-to-severe malnutrition (weight loss, anaemia, reduced muscle tone, pallor, delayed motor development), most frequently after surgery for gastroschisis or intestinal atresia. Following individualized enteral feeding, BMI increased from 14.8 ± 1.2 to 16.5 ± 1.0 kg/m² ($p<0.01$), the proportion with grade II–III malnutrition fell from 23.2% to 6.4% ($p<0.01$), and mean monthly weight gain increased from 320 ± 110 to 550 ± 140 g ($p<0.05$). Among 73 infants (27.8%) with constipation, unstable stool pattern or encopresis at baseline — predominantly those with Hirschsprung disease, anorectal malformations or intestinal atresia — bowel function normalized within 2–4 months in 81%, with complete resolution of encopresis in 12 patients. Of 44 infants with delayed motor development, 30 (68%) reached age-appropriate motor milestones within six weeks of targeted physiotherapy, and 14 achieved independent walking by 18 months.

Organizational outcomes and care continuity

Of 263 infants entering the program, 246 (93.5%) progressed through the hospital-to-outpatient continuum without a gap in follow-up; 102 families (38.8%) used telemedicine consultation, and more than 400 remote consultations were conducted overall, contributing to the avoidance of an estimated 28 hospitalizations. Specialist involvement across the cohort included pediatricians (100%), pediatric surgeons (89%), gastroenterologists (45.2%), dietitians (23.2%), physiotherapists (20.5%), psychologists (11.8%) and social workers (6.8%). Implementation of the program was associated with marked improvements in process indicators (Table 5): time from discharge to first rehabilitation-centre visit fell from 21 ± 4.3 to 6 ± 2.1 days ($p<0.01$), unplanned hospitalizations per patient-year fell by 41% (1.7 ± 0.4 to 1.0 ± 0.3), emergency reoperation fell from 4.2% to 0%, and parental treatment adherence rose from 53% to 87%.

Table 5. Organizational and process outcomes before and after implementation of the rehabilitation model.

Indicator	Before implementation	After implementation	Change
Time from discharge to first rehabilitation visit, days	21 ± 4.3	6 ± 2.1	−71%
Continuity of care coverage, %	40.2	93.5	+133%
Parental treatment adherence, %	53	87	+34%
Loss to follow-up, %	37	6	−31 pp
Unplanned hospitalizations per patient-year	1.7 ± 0.4	1.0 ± 0.3	−41%
Emergency reoperation, %	4.2	0	−100%

Parental psychosocial outcomes

At baseline, parents in both groups reported clinically significant anxiety on the STAI (program group 48.2 ± 6.1 vs comparison group 47.8 ± 6.3, $p>0.05$) and comparable caregiving confidence on the VAS (4.1 ± 1.2 vs 4.3 ± 1.1, $p>0.05$). After the intervention period, STAI scores fell substantially more in the program group (34.5 ± 4.8) than in the comparison group (42.9 ± 5.2, $p<0.001$), and VAS confidence rose more in the program group (7.3 ± 1.0) than in controls (5.8 ± 1.2, $p<0.001$) (Table 6). Higher parental confidence correlated with faster nutritional recovery ($r=0.64$, $p<0.05$) and fewer unplanned medical contacts ($r=-0.58$, $p<0.05$).

Table 6. Parental anxiety (STAI) and caregiving confidence (VAS) before and after the study period.

Measure / time point	Program group	Comparison group	p (between groups, post)	Effect size (post), Cohen's d
STAI, before	48.2 ± 6.1	47.8 ± 6.3	-	-
STAI, after	34.5 ± 4.8	42.9 ± 5.2	<0.001	1.69
VAS confidence, before	4.1 ± 1.2	4.3 ± 1.1	-	-
VAS confidence, after	7.3 ± 1.0	5.8 ± 1.2	<0.001	1.38

Within the wider program cohort, initial screening showed that 71% of parents (n=187) feared recurrent complications, 58% (n=153) reported uncertainty about feeding or stoma care, and 42% (n=111) reported emotional exhaustion. Structured caregiver education ("Parent School") was delivered to 89 families (33.8%), and targeted psychological support was provided to 31 families (11.8%) showing signs of emotional depletion or impaired parent–infant bonding. Families who completed the education curriculum showed faster nutritional recovery (approximately 1.3 months, $p<0.05$), a 2.2-fold reduction in unplanned hospitalization, and near-elimination of care-related repeat consultations.

Discussion

In this regional cohort from Central Asia, a structured, multistage, multidisciplinary rehabilitation program was associated with substantially better clinical, nutritional and psychosocial outcomes than standard postoperative care for infants with congenital gastrointestinal malformations. The program shortened hospital stay by approximately one week, roughly halved the rate of postoperative complications, and reduced 6-month readmissions to about one-third of the comparison rate. These findings are consistent with reports from specialized intestinal rehabilitation programs in high-income settings, where coordinated multidisciplinary care has been linked to improved survival and reduced morbidity in children with intestinal failure and short bowel syndrome (Modi et al., 2008), and align with consensus recommendations for enhanced-recovery pathways in neonatal intestinal surgery (ERAS® Society, 2020). Our results extend this evidence to a middle-income, regionally organized health system, suggesting that the core principles of multidisciplinary, protocolized postoperative care — rather than access to tertiary transplant-level resources — may account for much of the observed benefit.

The epidemiological findings reinforce the well-established association between adverse antenatal exposures — maternal anaemia, chronic somatic disease, late antenatal registration and environmental risk — and the occurrence of gastrointestinal malformations, and are broadly consistent with international data identifying congenital anomalies as a leading and largely preventable contributor to under-five mortality, disproportionately concentrated in low- and middle-income countries (Wright et al., 2019; GlobalPaedSurg Research Collaboration, 2021). The correlation we observed between the burden of antenatal risk factors and malformation severity, together with the identification of low birth weight, multiple malformations and delayed nutritional rehabilitation as independent predictors of adverse outcome, supports the use of a simple, clinically applicable risk-stratification model to prioritize infants for the most intensive components of postoperative rehabilitation.

Nutritional recovery was a particularly consistent benefit of the program, with meaningful gains in BMI, monthly weight velocity and serum protein/albumin concentrations, echoing evidence that individualized, protocol-driven nutritional support materially affects growth trajectories after major neonatal gastrointestinal surgery, especially in infants with gastroschisis and intestinal atresia who are at highest risk of prolonged parenteral nutrition dependence and growth faltering (Gonzalez et al., 2020). Improvement in gastrointestinal functional recovery was likewise consistent across all measured domains and time points, and was most pronounced among the historically difficult-to-manage subgroups — Hirschsprung disease and anorectal malformations — in which long-term bowel dysfunction is well documented even after technically successful definitive surgery (Baldanza et al., 2025). This suggests that multistage postoperative rehabilitation may partially offset, though not eliminate, the functional burden intrinsic to these malformations, reinforcing calls for lifelong, structured bowel-management follow-up in this population.

The psychosocial findings are clinically important in their own right. Parents of infants undergoing neonatal surgery for non-cardiac congenital anomalies experience stress levels comparable to, or exceeding, those reported in general neonatal intensive care populations, with parental role alteration and uncertainty about home care cited as principal stressors (Govindaswamy et al., 2020). Our data show that a structured education and psychological support program can materially reduce this burden, and — notably — that improvement in parental confidence correlated with objective clinical recovery, suggesting a bidirectional relationship between caregiver wellbeing and infant outcome that merits further mechanistic study. The telemedicine component appeared to contribute meaningfully to both convenience and safety, consistent with a growing body of evidence that remote follow-up after pediatric surgery is feasible, well accepted by families, and can reduce unnecessary in-person utilization without compromising safety (Goedeke et al., 2019).

This study has several limitations. Group allocation was not randomized; infants were assigned to the rehabilitation program largely on the basis of the

sequential regional rollout and logistic accessibility, introducing potential selection bias that our observational design cannot fully exclude. Formal statistical comparison of baseline birth weight, gestational age, and malformation-type distribution between the program and comparison groups was not tabulated for this cohort, so the possibility that the comparison group was systematically higher-risk cannot be excluded on the basis of the data presented here. Outcome assessment, particularly of parental psychosocial measures, was not blinded. Follow-up was limited to two years of age, precluding assessment of longer-term cognitive, educational and social outcomes, which are increasingly recognized as important endpoints for children surviving major neonatal surgery. The study was conducted within a single regional health system, which may limit generalizability to settings with different resource availability or organizational structures. The predictive model for adverse outcome (Section 3.2) was not internally validated by split-sample validation or bootstrapping, a limitation attributable to the constrained sample size of the high-risk subgroup. Finally, while the program bundled several interventions (nutritional, physiotherapeutic, psychosocial and telemedicine), the observational design does not allow the relative contribution of each component to be isolated; among the available process indicators, telemedicine showed the highest family uptake (38.8% of program families, Section 3.6) and completion of the parent education curriculum was associated with faster nutritional recovery and fewer unplanned hospitalizations (Section 3.7), suggesting these two components may have contributed disproportionately to the overall effect, though this cannot be confirmed without a component-isolating trial design.

Future work should prioritize prospective, ideally randomized or stepped-wedge, evaluation of the rehabilitation model; extension of follow-up to school age to capture neurodevelopmental and quality-of-life outcomes; development and validation of a composite functional recovery index integrating physical, nutritional, motor and family psychosocial domains; and formal economic evaluation to quantify the direct and indirect cost savings associated with reduced hospital stay and readmission. Expansion of the digital and telemedicine components, and integration with national electronic health record systems, may further improve the scalability of this model to other regions of Uzbekistan and to comparable health systems in Central Asia.

Conclusion

A multistage, multidisciplinary, family-centered rehabilitation program — combining individualized nutritional support, physiotherapy, structured parental education, psychological support and telemedicine-enabled follow-up — was associated with shorter hospital stay, fewer postoperative complications and readmissions, faster and more complete gastrointestinal functional recovery, improved nutritional status, and reduced parental anxiety in infants surgically treated for congenital gastrointestinal malformations in a regional health system in Uzbekistan. These findings support the wider adoption of multistage, coordinated postoperative rehabilitation as a standard component of care for this high-risk population, particularly in resource-constrained settings where such models are not yet routine.

Acknowledgements

Data Availability Statement: The datasets analysed in this study are available from the corresponding author upon reasonable request, in accordance with institutional data-sharing policies.

Ethics Statement: The studies involving human participants were reviewed and approved by [Institutional Ethics Committee, Samarkand State Medical University — №002, 16.03.2026]. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author Contributions: SZ: conceptualization, methodology, data curation, formal analysis, investigation, writing – original draft. JR: supervision, methodology, writing – review and editing. JS: supervision, methodology, writing – review and editing.

Funding: The authors declare that no specific funding was received for this work.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgments: The authors thank the staff of the Republican Perinatal Center and the Regional Children's Multidisciplinary Medical Center, Samarkand Region, for their assistance with data collection and clinical care.

Disclosure of AI Use: None.

References

1. Baldanza F, Grasso F, Pensabene M, Sergio M, Di Pace MR. Long-term bowel and urinary function outcomes and quality of life in patients with anorectal malformations: 20 years of experience. Children. 2025;12(8):1042. doi:10.3390/children12081042
2. ERAS® Society. Consensus guidelines for perioperative care in neonatal intestinal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. J Pediatr Surg. 2020;55(11):2401–10.
3. GlobalPaedSurg Research Collaboration. Mortality from gastrointestinal congenital anomalies at 264 hospitals in 74 low-income, middle-income, and high-income countries: a multicentre, international, prospective cohort study. Lancet. 2021;398(10297):325–39. doi:10.1016/S0140-6736(21)00767-4
4. Goedeke J, Ertl A, Zöller D, Rohleder S, Muensterer OJ. Telemedicine for pediatric surgical outpatient follow-up: a prospective, randomized single-center trial. J Pediatr Surg. 2019;54(1):200–7. doi:10.1016/j.jpedsurg.2018.10.014
5. Gonzalez KW, Dalton BGA, Weaver KL, Sherman AK, Aguayo P, Fraser JD, et al. Nutrition delivery and growth outcomes in infants with gastroschisis. JPEN J Parenter Enteral Nutr. 2020;44(2):267–74. doi:10.1002/jpen.1622
6. Govindaswamy P, Laing S, Waters D, Walker K, Spence K, Badawi N. Stressors of parents of infants undergoing neonatal surgery for major non-cardiac congenital anomalies in a surgical neonatal intensive care unit. J Paediatr Child Health. 2020;56(4):512–20. doi:10.1111/jpc.14673
7. Modi BP, Langer M, Ching YA, Valim C, Waterford SD, Iglesias J, et al. Improved survival in a multidisciplinary short bowel syndrome program. J Pediatr Surg. 2008;43(1):20–4. doi:10.1016/j.jpedsurg.2007.09.014
8. World Health Organization. Congenital anomalies. 2025. [cited 2025 Mar 14]. Available from: https://www.who.int/health-topics/congenital-anomalies
9. Wright NJ, Anderson JE, Ozgediz D, St-Louis E, Ameh EA, Formenti FJ, et al. Management and outcomes of gastrointestinal congenital anomalies in low, middle and high income countries: protocol for a multicentre, international, prospective cohort study. BMJ Open. 2019;9(8):e030452. doi:10.1136/bmjopen-2019-030452