Defining Standards and Core Outcomes for clinical trials in prehabilitation for colorectal Surgery (DiSCO): modified Delphi methodology to achieve patient and health-care professional consensus.

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Competing interests

There are no competing interests to declare.

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Key points

Abstract

Background

Prehabilitation is increasingly offered to patients before major colorectal surgery to try and improve outcomes but implementation is varied reflecting a lack of consensus on the optimum prehabilitation programme. The aim of this study was to agree core standards and outcomes for prehabilitation research through an international consensus process.

Methods

A long list of 186 items was compiled by systematic review and Patient and Public Involvement event. This was rationalized into 118 items across 9 domains which were rated via a two-round Delphi questionnaire by an international stakeholder group (clinicians, patients and allied healthcare professionals). 186 participants completed both rounds of the Delphi (Patients: n=30, HCPs n=156). 28 items reached the threshold for inclusion after Round 1 and 8 additional proposed items were added. A further 25 reached the threshold for inclusion after Round 2 with 32 consensus out. The 39 borderline items were discussed and voted on at two consensus meetings.

Results/Outcomes

33 core standards (what prehabilitation should include, who should be offered prehabilitation and who should be part of the prehabilitation team) and 21 core outcomes achieved consensus for utilization in future prehabilitation research.

Conclusion/Discussion

A set of core standards and outcomes for colorectal optimization has been agreed by international stakeholders, including patients. Utilization of these core standards and outcomes as a framework for future prehabilitation research will facilitate research synthesis enabling easier translation of research output into patient benefit.

Introduction

Elective colorectal surgery for benign and malignant conditions constitutes some of the most commonly performed operations worldwide [1]. Although mortality is reported as low (3%),

postoperative morbidity is common and can delay the patient's in-hospital recovery, reduce quality of life, carry a high risk of re-admission and even reduce cancer specific survival [2].

Prehabilitation is the process of physical, nutrition and psychological optimization prior to surgery and can augment the successes reported by Enhanced Recovery After Surgery (ERAS) programmes [3,4,5,6]. Demonstrated as safe and feasible in colorectal patients [7], early trial evidence has reported that prehabilitation reduces the number of patients suffering postoperative complications by 51% [8], as well as improving exercise capacity [9] and decreasing length of hospital stay [10].

To expedite prehabilitation research, systematic reviews have combined the small number of trials reporting that the heterogeneity of data limited comparison [11,12,13]. Limitations included differing inclusion criteria focusing on patents with a malignant diagnosis and overlooking those with a benign pathology, differing methodology and varying outcome measures. As a consequence, these reviews have concluded standards and outcome measures are required.

Development and implementation of a set of core standards and outcomes would encourage homogeneity of data and consequently improve the quality of the evidence base to enhance colorectal patients' care. Patient involvement is key as they remain underserved despite expressing a clear need to be involved [14,15,16,17]. The aim of the DiSCO (Defining Standards in Colorectal Optimisation) study was to achieve international consensus from patients and healthcare professionals on core standards and outcomes for clinical trials of prehabilitation in elective colorectal surgery.

Methods

Study overview.

The methodology was adapted from the Core Outcome Measures in Effectiveness Trials (COMET) handbook and the recommended standards for core outcome set development [18]. As the aim was to develop a core set of standards and outcomes, the COS-STAD methodology was adapted [19]. Ethical approval was granted (University of Glasgow College of Medical, Veterinary and Life Sciences Ethics Committee; 200190120). The study was registered with COMET Initiative (www.comet-initiative.org).

Core Standards and outcomes were developed in 3 stages: 1) long listing of standards and outcomes from systematic review and Patient and Public Involvement (PPI) day; 2) three rounds of Delphi process and 3) consensus meeting to review Delphi survey results. The protocol for the study has been published [20].

Scope

The scope of the core standards and outcomes agreed in this study is defined in line with the COS-STAD recommendations: The intended use of the core standards and outcomes (setting) is for research and clinical practice; the health condition was colorectal disease, population adults over 18 years of age, and the intervention was prehabilitation prior to surgery. Colorectal disease was defined as any benign or malignant colorectal conditions treated with elective resection of a part/ all of the colon, rectum or anus for. These conditions included, but not limited to colorectal cancer, anal cancer, diverticulitis and its' complications, inflammatory bowel disease and pelvic floor dysfunction.

Steering Group and Stakeholders

To ensure inclusivity and diversity of all potential stakeholders and participants, leading national and international professional bodies in colorectal disease and/ or those endorsing prehabilitation and/ or components of prehabilitation (nutrition, activity/ exercise, psychological) were identified and approached [Appendix 1]. An international steering group (surgeons, exercise specialists, psychologists) was set up to identify these professional bodies and to ensure widespread distribution of the Delphi Survey and consensus days through social

media (@DiSCO_Study). This work is co-produced with patients, evidenced by a patient research partner as a lead member of the steering group responsible for the design, planning and delivery and patient networks and inclusion of patient-centred professional groups and charities as stakeholders and participants.

Stage 1: Long-listing

The long list of standards and outcomes was extracted from a systematic review [11]. This was supplemented by the outputs from a PPI day involving patients and carers to ensure that standards and outcomes of importance to patients were included in the final longlist. Field notes from the PPI day were transcribed verbatim and thematic analysis was performed to allow interpretation and themes to be taken forward to the long list [Appendix 2].

The final long list of standards and outcomes were reviewed by the steering group for definition, clarity and for plain English, and used to populate the Delphi questionnaire with clear definitions and plain language descriptions accompanying each item [Appendix 3].

Stage 2: Delphi Survey

A two-round modified Delphi questionnaire was conducted (DelphiManager platform) and participants registered online via the COMET Delphi Manager. The registration process included consent to take part in the study, and captured name, email, stakeholder group (patient or healthcare professional, HCP), country of residence, occupation (for HCPs).

During each round, participants were asked to rate the importance of each of the item using the recommended Likert scale from 1 (not important) to 9 (critically important) [21]. With this scale, 1 to 3 signifies the item is of little importance, 4 to 6 some importance and 7 to 9 critical importance. At the end of round 1, participants were invited to suggest any additional items for inclusion in round 2. Participants who completed round 1 were sent an email invitation to participate in round 2, followed by one reminder. In round 2 participants reviewed the scores they had given items in round 1 alongside the summarised scores of other participants (as histograms) stratified by stakeholder group, before re-scoring each item.

Consensus criteria

To reduce bias, predetermined consensus thresholds were used: items ranked as of critical importance (7-9) by at >=70% and of little importance (1-3) by =<15% of participants in both stakeholder groups were categorised as "consensus-in". Items ranked as of critical importance (7–9) by =< 50% or of little importance (1–3) by >=50% participants in both stakeholder groups were categorised as "consensus-out". Any items not reaching either the threshold for "consensus-in" or "consensus-out" were considered "borderline" [Table 1].

Outcomes meeting the criteria for "consensus-in" after Round 1 of the Delphi were directly added to the final shortlist and not included in subsequent rounds. All other items (consensus-out and borderline) were taken forward to Round 2. After Round 2 any additional items reaching the threshold for "consensus-in" were directly added to the shortlist. Any items ranked "consensus-out" were excluded. All borderline outcomes were taken forward for discussion at the consensus meeting.

Protocol deviation

Following round 2, 53 items had already achieved the predefined threshold for consensus and the steering group agreed that there was little additional benefit in asking participants to complete a third round of the Delphi and risk further attrition of participants through questionnaire fatigue.

Stage 3: Consensus Meeting

Due to COVID restrictions and to allow international participation, two online consensus meetings were planned (one for standards, one for core outcomes) and held on consecutive days, at different times. Participants who had completed any of the rounds of the Delphi were invited with additional potential participants recruited via Twitter and direct e-mail. Purposive sampling of potential participants was undertaken to ensure as wide a range of geographic and stakeholder representation as possible. Voting during the consensus meeting was conducted using Mentimeter (www.mentimeter.com) which allowed electronic consent to be taken. Participants were asked to select their stakeholder group at the start (patient or HCP). The meeting was co-chaired: one author with experience in consensus meeting facilitation and core outcome set development methodology (RF) and the other a patient research partner experienced in health consensus meetings (SB). The consensus meeting summarised

the aims of the project and the items that had already achieved consensus (SM, RF). Participants were asked if there were any objections. Borderline items were then discussed systematically through the 9 domains and voted on. Contrasting views were actively sought. Stakeholder stratification of voting results and the criteria for consensus were the same as those used in the Delphi survey with the results displayed immediately after voting for each item (as histograms stratified by stakeholder group). At the end of the meeting the final core standards and outcomes set were displayed and ratified.

Results

Long-listing

186 items were identified from the systematic review [11] [Figure 1]. Thematic analysis of the PPI day identified ten themes from the 4 headings [Appendix 2]. These items and themes were combined by the steering group. After merging closely related items and exclusion of items that were deemed clinically inappropriate or out of context, the final longlist included 118 items across 9 domains: components of prehabilitation, setting of prehabilitation, exercise/ physical activity, nutrition, psychological support, comprehensive geriatric assessment, recipients of prehabilitation, delivery of prehabilitation and outcomes [Appendix 3].

Delphi Survey

289 participants from 18 different countries registered for round one: 51 patients and 238 healthcare professionals. Of the 289, eight participants did not answer any questions (four HCPs and four patients) and 233 participants (198 HCPs and 35 patients) answered all questions. The demographic information for Delphi participants is summarised in Table 3.

Round one was open for 10 weeks in total, extended from the planned 6-7 weeks to maximise participant numbers and accommodate the Christmas and New Year vacation period.

After round 1, 28 items achieved consensus-in (Figure 1). Participants proposed 56 additional items. After steering group review eight items were included with the rest excluded as either: already included, or not within the scope of the study (being neither a standard nor outcome). A total of 98 items were taken forward to round 2.

Round 2 was opened 4 weeks after round 1 closed and was open for 7 weeks. 186 people (156 HCPs and 30 patients) answered all questions. 25 items achieved consensus-in and 34 consensus-out. A total of 39 items meeting the criteria for “borderline” were taken forward to the consensus meetings.

Excluding participants who registered but did not answer any questions, attrition from round 1 to 2 was 34% (HCPs 34%, patients 36%). Amongst participants who answered all questions in round1, attrition from round 1 to 2 was 20.1% (HCP 21%, patients 14%).

Consensus meetings

The standards and outcome consensus days were attended by 34 (HCP 24, patient 9) and 26 (HCP 20, patient 6) participants respectively (Table 3). 8.3% attended both days.

Core Standards

25 borderline items spanning 5 domains were considered: setting for prehabilitation, exercise/ physical activity, nutrition, psychological support and who should deliver prehabilitation. The standards in the remaining domains had already achieved consensus. The steering group proposed re-discussion of 15 items that were consensus-out in the Delphi but were closely related to borderline items that were being discussed, meaning a total of 40 items were considered.

Setting for prehabilitation was the first to be re-discussed. HCPs felt that the localisation of the settings was too specific and that patients need different options depending on distance to the hospital and access to transport. Similar themes emerged in the discussion of the medium (e.g. face-to face or virtual) and in relation to the physical activity, exercise, and nutrition domains.

The remainder of re-discussed items were to allow exchange on of all the options rather than individual items, for example the options for duration of the physical activity, nutritional, and psychological support interventions. Re-discussion allowed different durations to be agreed. It was thought that physical function could be improved, especially in the less fit or frail, within a short space of time (consensus 2-4 weeks). Psychological support was also thought to be potentially effective after 2 weeks, but some patients may need longer (consensus 2-6 weeks). After more evidence for the optimal duration of nutrition optimisation was introduced by participants, the group wanted to reflect the wide range of surgical colorectal pathologies included and agreed on a nutrition duration of 4-6 weeks.

In total there were 57 items reaching consensus-in that were grouped into 33 core standards for future prehabilitation research [Table 4a].

Outcomes

The steering group proposed grouping items into 6 domains based on the recommended outcome taxonomy from the COMET initiative [22]: physiological/ clinical; life impact; global quality of life and wellbeing, adverse events, death and resource use. The domain allocation of the 16 items that had achieved consensus-in was agreed by participants. Ten outcomes which had met the criteria for consensus-in and one which met the criteria for consensus-out were re-introduced due to potential overlap with the 14 borderline outcomes (Figure 1).

Two items re-introduced for discussion were overall quality of life and overall health and wellbeing. Both had achieved consensus-in and were considered for merging into one item called “global quality of life and wellbeing”. Terminology was explained and discussion facilitated. Participants felt that these items addressed sufficiently different concepts and following a vote left these in as two separate items.

The chair introduced that some outcomes were already included in other published core outcomes sets (COS) relevant to colorectal surgery. Examples stated were the COS for colorectal cancer surgery (included cancer recurrence), inflammatory bowel disease and to recovery of the bowel after surgery [23,24,25]. The group agreed that future trials of prehabilitation should refer to the relevant condition-specific COS where available in addition to this COS.

Length of hospital stay was a borderline item that the group acknowledged was commonly included in research studies. This item was thought to be influenced by many factors and was not a representative marker of prehabilitation success, especially if older adults were involved that required social care input. In contrast, length of critical care was thought not to be as susceptible to influences by other factors and achieved consensus.

Physical function items were thoroughly explored and the chair steered the group to achieve consensus on what should be measured, rather than specifying what measurement to use.

There were contrasting views on the role of invasive and non-invasive tests (CPET versus 6-minute walk test). The reproducibility of CPET and the supporting evidence was highlighted with non-invasive tests seen as being more variable in their results, but potentially better tolerated. Alternate wording was proposed through group discussion and the following reached consensus: 'any suitable objective measure of physical function' and 'any suitable objective measure of cardio-respiratory function' (physical function domain).

The outcome 'return to normal activities' was discussed and consensus was that this should be modified to 'return to normal physical activity' and included in the physical function domain rather than the life impact domain. Post-operative course after discharge from hospital was voted out after discussion. Although it achieved consensus-in previously, the group thought it was non-specific and covered by other items such as discharge destination and support requirements (Resource Use domain) and Global quality of life (Life Impact domain). Discharge destination and support was also voted to be combined into one item with family/ carer support (Resource Use domain).

The items 'planned treatment does not go ahead'; 'inability to complete physical tests' and 'prehabilitation stopped' were considered and consensus-out was reached as these items represented process measures rather than outcomes.

In total the 27 items which achieved consensus were grouped, resulting in 21 Core Outcomes in 6 domains for future prehabilitation research (Table 4b).

Discussion

This international work including all stakeholders and patients, is the first to provide consensus on core standards and outcomes in clinical trials for prehabilitation in colorectal surgery. Prehabilitation research is an active and evolving area making publication of this work timely.

Standards Consensus

It has been clearly stated that patients value variation and choice in prehabilitation trials. Demonstrated by the comments: “not one-size-fits-all" “[prehabilitation should be] tailored to your needs”, prehabilitation research cannot focus on just one programme and there should be consideration towards the needs of the individual. The consensus days introduced the widely used clinical term of ‘exercise prescription’ that the group favoured if it was individualised. Participants, both patients and HCPs appreciated this individualised approach has to work around potentially multi-modal treatment, resources, funding and what is deliverable, but wanted recognition that virtual or distant prehabilitation programmes were an option that could engage wider recruitment from harder to reach populations e.g. patients living at a distance from the hospital or local community.

Terminology needs to be considered. Patients reported that they found the term High intensity interval training (HIIT) intimidating. HIIT was then described in detail with supporting evidence, and although HIIT was not specifically included, there was consensus that aerobic training and anaerobic training should be included. This allows future research to include any type of exercise that can provide overload, but the chair did stress that key standards are not prescriptive and are typically ‘what should be included’ not the ‘how it should be included’.

Finally, the importance of prehabilitation not being a sole entity was strongly supported and that it should flow into established programmes like ERAS and rehabilitation.

Core Outcomes Consensus

Prehabilitation research has rarely focused on emotional wellbeing. The inclusion of a range of life impact and quality of life and wellbeing outcomes in this set highlights the value of interaction between HCPs and patients and the extent to which patient priorities have been underreported in the field of prehabilitation research. Patient Activation Measures (PAMs) is

such an example. This validated measurement was explained to all participants as many were unfamiliar. However, discussion reflected broad agreement that PAMs were important and valuable with voting achieving consensus.

The strong support for considering other relevant COS in prehabilitation work was evident. This conclusion is in line with many regulatory authorities and guideline development groups (UK National Institute for Health Research and European Medicine Agency, UK national Institute for Health and Care Excellence) supporting standards and core outcome sets as a driver for improving research.

Strengths

The aim to co-produce with patients was achieved with a patient research partner as a lead investigator, a dedicated PPI event informing the longlisting process and engagement of patients and patient groups through each step of the Delphi process. Consideration for the multiple stakeholders involved in prehabilitation research was paramount and the DISCO Delphi process and consensus meeting brought these experts together to reach consensus. The final strength is inclusion of benign conditions that despite being a large patient population, are often overlooked in prehabilitation research.

Limitations

In common with many consensus studies, it is likely that recruitment bias is present. Individuals who did not feel willing or able to participate might differ in opinions from those who did participate. Combing standards and core outcomes resulted in a lengthy long list that may account for the attrition rate between rounds. The steering group did initially consider focussing on core outcomes only, but the strong interplay between the standards and outcomes meant that we included both. Finally, there was predominance from European countries with very few low-income countries. This reflects the distribution of published prehabilitation research worldwide.

Conclusion

The DiSCO core standards and outcomes represent the consensus opinion of international stakeholders involved in prehabilitation research in colorectal surgery. Application of the DiSCO core standards and outcomes for current and future trials will create a common language that should facilitate comparative evidence synthesis, thereby accelerating translation of prehabilitation research into patient benefit.

Contribution statement

SM, SB, and RF planned and designed the study. Systematic review was led by SD. PPI day developed and run by SM, IP and SB. Long listing performed by the steering team, SM, SB, RF, SD, MW. RF set up and administered the Delphi survey. SM set up the stakeholders list and contacts. RF and SRK analysed the Delphi results and structured the consensus days. In addition to RF, SB and SRK facilitating the consensus meetings, assistance was provided by CB, JN, MT. Steering group produced the first written draft with all authors approached for revision and subsequent agreement of the final draft.

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Table 1: Consensus criteria for Delphi questionnaire and consensus meeting.

Percentage of participants scores		**Patients**			
		>=70% 7-9 AND <15% 1-3	50-70% 7-9	<50% 7-9	>=50% 1-3
HCP	>=70% 7-9 AND <15% 1-3	Consensus-in	Borderline	Borderline	Borderline
	50-70% 7-9	Borderline	Borderline	Borderline	Borderline
	<50% 7-9	Borderline	Borderline	Consensus-out	Borderline
	>=50% 1-3	Borderline	Borderline	Borderline	Consensus-out

Figure 1: Flow of Items of Standards and Core Outcomes through DiSCO Delphi.

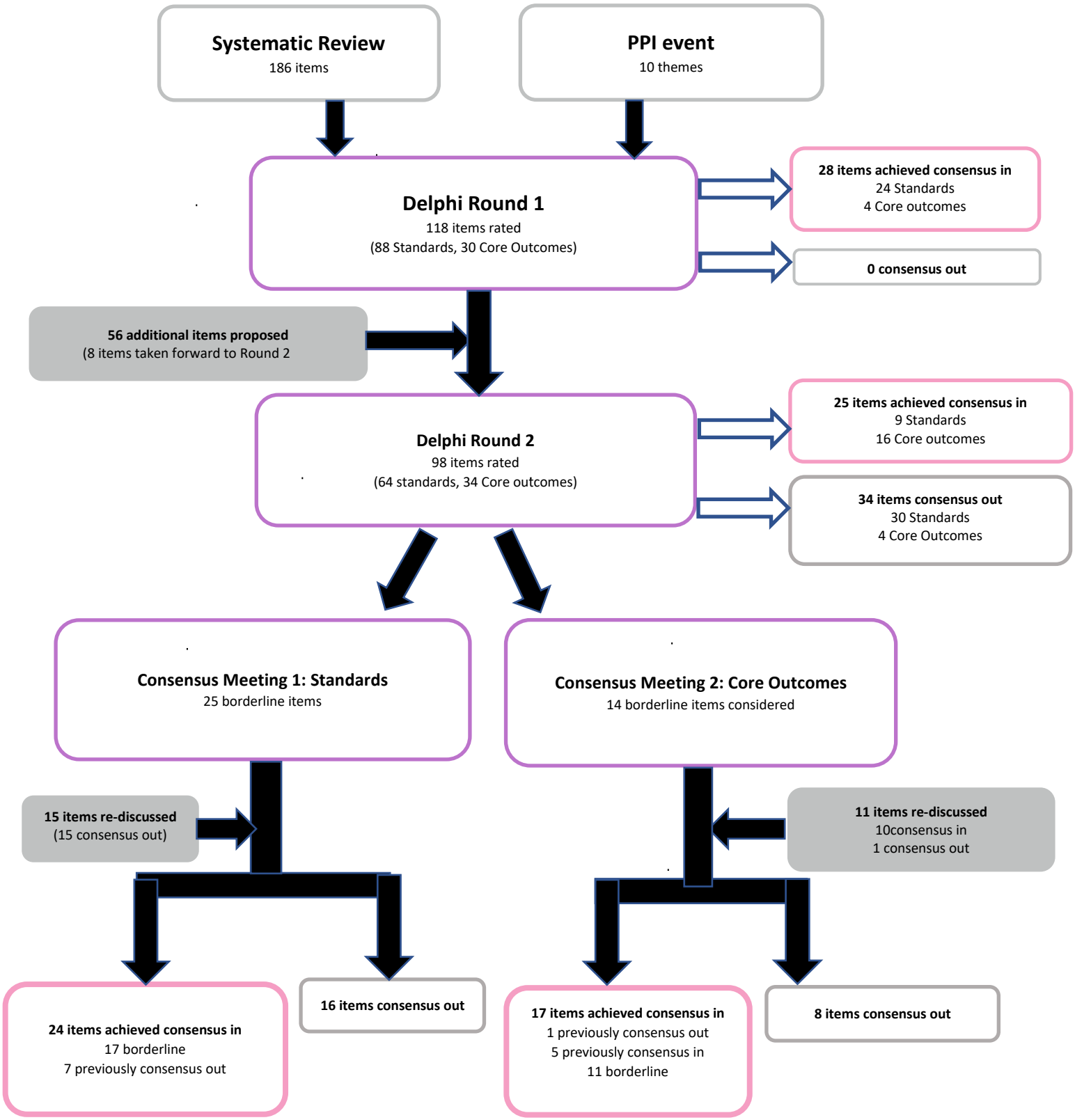

Table 2: Summary of DiSCO Delphi results through Rounds 1 and 2 and the Consensus days.

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
Components of Prehab		Exercise/ physical activity	1	Yes	n/a	n/a	Exercise
		Nutrition	2	Yes	n/a	n/a	Nutrition
		Psychological support	3	Yes	n/a	n/a	Psychological (emotional) support
		Comprehensive geriatric assessment (for older; frail patients)	4	Yes	n/a	n/a	Comprehensive geriatric assessment (for older; frail patients)
Setting for Prehab		In secondary care (the hospital) #	5	Consensus-out	Consensus-out	Yes	Multi-centre
		In primary care (the GP's practice) #	6	Consensus-out	Consensus-out	Yes	
		In the community; for example at a local gym or community centre#	7	Consensus-out	Consensus-out	Yes	
Exercise/ Physical Activity	Medium	Face-to face exercise supervision and advice#	8	Consensus-out	Consensus-out	Yes	Choice of face to face or remote
		Remote exercise supervision and advice (e.g. by telephone or video-call) #	9	Consensus-out	Consensus-out	Yes	
	Group size	One-to-one exercise supervision and advice	10	Consensus-out	Borderline	Yes	Choice of one-to-one or group
		Group exercise supervision and advice#	11	Consensus-out	Consensus-out	Yes	
	Personalisation	A personalised exercise programme specifically tailored to the individual	12	Consensus-out	Borderline	Yes	A personalised exercise programme specifically tailored to the individual
		A standardised exercise programme designed for prehab but not specifically tailored to each individual#	13	Consensus-out	Consensus-out	No	
		General exercise advice not specifically designed for prehab	14	Consensus-out	Consensus-out	n/a	
	Type	Exercise that becomes progressively harder	15	Consensus-out	Consensus-out	n/a	

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		High intensity/interval training	16	Consensus-out	Consensus-out	n/a	
		Endurance	17	Consensus-out	Consensus-out	n/a	
		Pulmonary physiotherapy exercises	18	Consensus-out	Borderline	No	
		Functional activity training	19	Consensus-out	Borderline	Yes	Functional activity training
		Cardiovascular /aerobic exercise	20	Consensus-out	Borderline	Yes	Cardiovascular /aerobic exercise
		Resistance/weight training	21	Consensus-out	Consensus-out	n/a	
		Stretching/flexibility exercise	22	Consensus-out	Borderline	No	
	Duration	The exercise programme should last up to 2 weeks#	23	Consensus-out	Consensus-out	No	
		The exercise programme should last 2-4 weeks	24	Consensus-out	Borderline	Yes	The exercise programme should last 2-4 weeks
		The exercise programme should last 4-6 weeks	25	Consensus-out	Borderline	No	
		The exercise programme should be in excess of 6 weeks#	26	Consensus-out	Consensus-out	No	
Nutrition	Medium	Face-to face nutritional advice	27	Consensus-out	borderline	Yes	Choice of face to face or remote
		Remote nutritional advice (e.g. by telephone or video-call)	28	Consensus-out	Borderline	Yes	
	Group size	One-to-one nutritional advice	29	Consensus-out	Borderline	Yes	One-to-one nutritional advice
		Group nutritional advice#	30	Consensus-out	Consensus-out	No	
	Personalisation	A personalised nutritional advice programme specifically tailored to the individual	31	Consensus-out	Borderline	Yes	A personalised nutritional advice programme specifically tailored to the individual

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		A standardised nutritional advice programme designed for prehab but not specifically tailored to the individual#	32	Consensus-out	Consensus-out	No	
		General nutritional advice#	33	Consensus-out	Consensus-out	No	
	Duration	The nutrition programme should last up to 2 weeks#	34	Consensus-out	Consensus-out	No	
		The nutrition programme should last 2-4 weeks	35	Consensus-out	Borderline	No	
		The nutrition programme should last 4-6 weeks	36	Consensus-out	Borderline	Yes	The nutrition programme should last 4-6 weeks
		The nutrition programme should be in excess of 6 weeks#	37	Consensus-out	Consensus-out	No	
Psychological Support	Medium	Face-to face psychological support	38	Consensus-out	Borderline	Yes	Choice of face to face or remote
		Remote psychological support (e.g. by telephone or video-call)	39	Consensus-out	Borderline	Yes	
	Group size	One-to-one psychological support	40	Consensus-out	Borderline	Yes	One-to-one psychological support
		Group psychological support	41	Consensus-out	Consensus-out	n/a	
	Personalisation	A personalised psychological support programme specifically tailored to the individual	42	Consensus-out	Borderline	Yes	A personalised psychological support programme specifically tailored to the individual
		A standardised psychological support programme designed for prehab but not specifically tailored to the individual	43	Consensus-out	Consensus-out	n/a	
		General advice on psychological support	44	Consensus-out	Consensus-out	n/a	
	Type	Focus on anxiety reduction	45	Consensus-out	Yes	n/a	Focus on anxiety reduction

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		Focus on body image including stoma concerns	46	Consensus-out	Yes	n/a	Focus on body image including stoma concerns
		Relaxation techniques e.g. breathing exercises; yoga	47	Consensus-out	Borderline	Yes	Relaxation techniques e.g. breathing exercises; yoga
		Mental preparedness and motivation	48	Borderline	Yes	n/a	Mental preparedness and motivation
	Duration	The psychological support should last up to 2 weeks	49	Consensus-out	Consensus-out	n/a	
		The psychological support should last 2-4 weeks#	50	Consensus-out	Consensus-out	Yes	Psychological support should last 2-6 weeks
		The psychological support should last 4-6 weeks	51	Consensus-out	Borderline	Yes	
		The psychological support should be in excess of 6 weeks	52	Consensus-out	Borderline	No	
Comprehensive Geriatric Assessment		Cognitive assessments	53	Yes	n/a	n/a	All components of the comprehensive geriatric assessments
		Medication optimisation	54	Yes	n/a	n/a	
		Co-morbidity review	55	Yes	n/a	n/a	
		Falls advice	56	Yes	n/a	n/a	
		Advanced care planning	57	Yes	n/a	n/a	
Recipients of Prehab	Reason for surgery	Patients undergoing surgery for benign conditions	58	Consensus-out	Yes	n/a	All types of colorectal surgery for any condition, including patients having neoadjuvant chemotherapy
		Patients undergoing surgery for cancer	59	Yes	n/a	n/a	
	Surgical approach	Patients undergoing laparoscopic (keyhole) surgery	60	Consensus-out	Yes	n/a	
		Patients undergoing open surgery	61	Yes	n/a	n/a	
	Neoadjuvant treatment	Patients undergoing chemotherapy or radiotherapy prior to surgery	62	Yes	n/a	n/a	
	Stoma	Patients having a stoma formed as part of surgery	63	Yes	n/a	n/a	
	Age of patient	Patients under 60 years of age	64	Borderline	Yes	n/a	Patients of any age

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		Patients aged 60-69	65	Yes	n/a	n/a	
		Patients aged 70-79	66	Yes	n/a	n/a	
		Patients aged 80-89	67	Yes	n/a	n/a	
		Patients aged 90 and over	68	Yes	n/a	n/a	
	Comorbidities and risk factors	Frail patients	69	Yes	n/a	n/a	Patients with any co-morbidities and additional risk factors
		High-risk' patients	70	Yes	n/a	n/a	
		Malnourished/underweight patients	71	Yes	n/a	n/a	
		Obese patients	72	Yes	n/a	n/a	
		Patients with recent or long-term mental illness	73	Yes	n/a	n/a	
Delivery of Prehab		Surgeon	74	Consensus-out	Consensus-out	n/a	
		Anaesthetist	75	Consensus-out	Consensus-out	n/a	
		Specialist nurse	76	Yes	n/a	n/a	Specialist nurse
		Oncologist (medical or clinical)	77	Consensus-out	Consensus-out	n/a	
		Exercise physiologist or sports scientist	78	Consensus-out	Yes	n/a	Exercise physiologist or sports scientist
		Exercise oncologist	79	Consensus-out	Borderline	No	
		Sports medicine specialist	80	Consensus-out	Consensus-out	n/a	
		Exercise/activity specialist e.g. a personal trainer	81	Consensus-out	Borderline	No	

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		Physiotherapist	82	Borderline	Yes	n/a	Physiotherapist
		Nutritionist/dietician	83	Yes	n/a	n/a	Nutritionist/dietician
		Geriatrician	84	Consensus-out	Borderline	No	
		Pharmacist	85	Consensus-out	Consensus-out	n/a	
		Psychologist	86	Borderline	Yes	n/a	Psychologist
		General practitioner (GP)	87	Consensus-out	Consensus-out	n/a	
		Other patients who are having/have had colorectal surgery	88	Consensus-out	Borderline	Yes	Other patients who are having/have had colorectal surgery
Outcomes of Prehab	Physical musculoskeletal function	Daily or weekly Step count#	89	Consensus-out	Consensus-out	Yes	A suitable objective measure of physical function
		Sit-to-stand	91	Consensus-out	Borderline		
		6 minute walk test	92	Consensus-out	Borderline		
		Handgrip strength	95	Consensus-out	Borderline		
		Leg strength (e.g. leg/ quadriceps extension)	96	Consensus-out	Borderline		
	Cardio-respiratory function	Respiratory/breathing measurements e.g. peak flow	93	Consensus-out	Borderline	Yes	A suitable physiological measure of cardiorespiratory fitness
		CPET	90	Consensus-out	Borderline		
		Pulse wave velocity*	119		Borderline		
	Metabolism and nutrition	Percentage body fat	97	Consensus-out	Consensus-out	n/a	
		Weight change	98	Consensus-out	Consensus-out	n/a	

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
		Energy expenditure	99	Consensus-out	Consensus-out	n/a	
		Change in nutritional assessment	100	Consensus-out	Yes	n/a	Change in nutritional assessment
	Psychiatric/Emotional functioning/well being	Cognitive issues	111	Borderline	Yes	n/a	Cognitive issues
		Anxiety	102	Borderline	Yes	n/a	Anxiety
		Depression	103	Consensus-out	Yes	n/a	Depression
		Stoma concerns	104	Consensus-out	Yes	n/a	Stoma concerns
		Stress	105	Consensus-out	Yes	n/a	Stress
	General	Pain	107	Borderline	Yes	Yes	Pain
	Physical function	Sleep	106	Consensus-out	Yes	Yes	Sleep
		Bowel function	108	Consensus-out	Borderline	Yes	Bowel function
		Return to normal activities	110	Yes	n/a	Yes	Return to normal physical activities
		Fatigue	101	Borderline	Yes	Yes	Fatigue
	Neoplastic	Cancer recurrence*	122		Borderline	Yes	Relevant condition-specific outcomes with reference to the relevant core outcome set where available
	Survival	Survival*	120		Yes	n/a	Survival
	Global quality of life and wellbeing	Overall quality of life	109	Yes	n/a	n/a	Overall quality of life
		An overall measure of health and functioning e.g. WHODAS or DASI score*	121		Yes	n/a	An overall measure of health and functioning
	Resource use	Length of hospital stay	112	Consensus-out	Borderline	No	
		Length of critical care stay (High dependency unit or intensive care) #	114	Borderline	Yes	No	

DOMAIN	Subdomain	ITEM	ID	Delphi R1	Delphi R2	Consensus meeting	Final key standards and core outcomes
	Adverse events	Surgical complications	113	Yes	n/a	n/a	Relevant condition-specific outcomes with reference to the relevant core outcome set where available
	Societal/carer burden	Discharge destination and support requirements#	115	Yes	n/a	Yes	Discharge destination and support requirements
		Post-operative course after discharge from hospital*#	125		Yes	No	
		Family/carer involvement*	126		Borderline	Yes	Family/carer involvement
	Process measures	Planned surgery does not go ahead#	117	Borderline	Yes		
		Prehabilitation stopped#	118	Consensus-out	Yes		
		Adherence to rehabilitation e.g. number of exercise sessions completed	94	Consensus-out	Borderline	No	
		Inability to complete physical tests#	116	Consensus-out	Yes		
	Behavioural	Changes in lifestyle behaviours*	123		Borderline	No	
		Patient Activation Measures*	124		Borderline	Yes	Patient Activation Measures

Table 3: Participant Characteristics.

		Delphi		Consensus meetings	
		Round 1	Round 2	Standards	Outcomes
Participants	Patient	51	30	9	6
	Healthcare Professionals	236	163	25	20
	Anaesthetist	24	17	4	2
	Exercise Specialist	6	5	1	0
	Exercise physiologist/ sports scientist	5	4	0	1
	General Practitioner	2	2	0	0
	Geriatrician	8	3	1	0
	Nutritionalist/dietician	29	17	4	2
	Oncologist	1	1	0	0
	Physiotherapist	16	11	2	2
	Psychologist	1	1	0	0
	Specialist Nurse	22	11	1	2
	Surgeon	110	81	9	8
	Unknown	0	0	3	3
Country of residence/practice		Rounds 1 & 2			
	Europe	239		19	21
	North America	17		3	2
	Australasia	23		0	2
	Asia	2		2	1
	Other	6		0	0

Table 4a: Final Set of Core Standards for Prehabilitation Research in Colorectal Surgery.

Domain	Subdomain	Standards (n=33)
Components of Prehabilitation		Exercise Nutrition Psychological (emotional) support Comprehensive geriatric assessment (for older; frail patients)
Setting for Prehab		Multicentre options
Exercise/ Physical Activity	Medium	Choice of face to face or remote
	Group Size	Choice of one-to-one or group
	Personalisation	A personalised exercise programme specifically tailored to the individual
	Type	Functional activity training Cardiovascular /aerobic exercise
	Duration	The exercise programme should last 2-4 weeks
Nutrition	Medium	Choice of face to face or remote
	Group size	One-to-one nutritional advice
	Personalisation	A personalised nutritional advice programme specifically tailored to the individual
	Duration	The nutrition programme should last 4-6 weeks
Psychological support	Medium	Choice of face to face or remote
	Group size	One-to-one psychological support
	Personalisation	A personalised psychological support programme specifically tailored to the individual
	Type	Focus on anxiety reduction Focus on body image including stoma concerns Relaxation techniques e.g. breathing exercises; yoga Mental preparedness and motivation
	Duration	Psychological support should last 2-6 weeks
Comprehensive Geriatric Assessment (CGA)		All components of the comprehensive geriatric assessments
Recipients	Reason for Surgery	All types of colorectal surgery for any condition, including patients having neoadjuvant chemotherapy
	Age	Patients of any age
	Comorbidities and risk factors	Patients with any co-morbidities and additional risk factors
Delivery of Prehab		Specialist nurse Exercise physiologist or sports scientist Physiotherapist Nutritionist/dietician Psychologist Other patients who are having/have had colorectal surgery

Table 4b: Final Core Outcome Set for Prehabilitation Research in Colorectal Surgery.

Domain	Subdomain	Core Outcome Set (n=21)
Physiological/clinical	Musculoskeletal	A suitable objective measure of physical function
	Cardiorespiratory	A suitable physiological measure of cardiorespiratory fitness
	Metabolism and Nutrition	Nutritional assessment
	General	Pain
	Neoplastic	Relevant condition-specific outcomes with reference to the relevant core outcome set where available
Life impact	Physical Function	Sleep Bowel function Return to normal physical activities Fatigue
	Psychiatric/Emotional functioning	Cognitive issues Anxiety Depression Stoma concerns Stress
	Behavioral	Patient activation measures
Global quality of life and wellbeing		Overall quality of life An overall measure of health and functioning
Adverse events	Adverse events	Relevant condition-specific outcomes with reference to the relevant core outcome set where available
Death	Survival	Survival
Resource Use	Societal/carer burden	Discharge destination and support requirements Family/ carer involvement

Appendix 1: List of Participating Professional Bodies.

Professional Body
ISBNPA (International Society of Behavioural Nutrition and Activity)
SPARC (Scottish Physical Activity Research Connections)
SCPN (Scottish Cancer Prevention Network)
ASGBI (The Association of Surgeons of Great Britain and Ireland)
ACPGBI (The Association of Coloproctology of Great Britain and Ireland)
TriPOM/ RCoA (Royal College of Anaesthetists and TriPom - Trainees with an interest in perioperative medicine),
NERCI/ ERAS Association; National Enhanced Recovery after Colorectal Surgery Initiative)
MacMillan Cancer Support
Bowel Cancer UK
Crohn's and Colitis UK
Ileostomy Association UK
Colostomy UK
CSSANZ (Colorectal Surgical Society of Australia and New Zealand)
ERAS plus, Manchester, UK
ESCP (European Society of Coloproctology).
ASCRS (American Society of Colorectal Surgeons).

Appendix 2: Thematic analysis of Prehabilitation in Colorectal Surgery PPI event.

	Theme	Definition	Exemplar Quote(s)
What should a prehabilitation programme include?	Importance of all proposed aspects	All possible components which were posed to and by the group were agreed to be important to offer in a prehabilitation programme. This includes physical activity, psychological support, smoking cessation, nutritional advice, alcohol support, medication review, stoma care, and financial advice.	"definitely need to involve activity" "psychological support seems to be essential" "specialist diet input important"
	Tailoring of prehabilitation programme	Participants agreed that prehab would be beneficial for all those undergoing elective colorectal surgery, but that everyone will require different focus to meet their needs. Methods to tailor the programme were proposed, including: patient completes a questionnaire to 'opt-in' to aspects of prehab; both surgeon and patient fill in questionnaire and compare discrepancies to decide together on suitable programme; or surgeon alone completes the questionnaire and presents the appropriate prehab programme to the patient. Options involving the patient were most popular, as it is "empowering" for the patient to have a role in decision making.	"not one-size-fits-all" "[prehabilitation should be] tailored to your needs" "those who are physically fit might not be mentally fit" "ask [patients] 'what matters to you?'"
	Offer as part of treatment	Participants identified that some patients may be unwilling to engage in a prehabilitation programme if it is seen as an "add-on" to the surgical treatment, and instead it should be presented as a mandatory aspect of the treatment process. They explained managing the language around prehabilitation as treatment is important, that it must be referred to as "part of your treatment".	"call it part of the treatment" "[refer to prehab as] part of the treatment package"
Who should be offered prehabilitation?	All patients should receive prehabilitation	It was unanimously agreed that all patients undergoing elective colorectal surgery should be offered prehabilitation.	"obvious answer is everyone"
Who should be part of the prehabilitation team?	Surgeon and patient as key team members	There was some discrepancy in opinions about who should form the core prehabilitation team, but the most common answer was that surgeon and patient should be involved in decision making at the start, and the team will expand to involve other roles as required.	"surgeon should be the one to tailor the prehab to the patient" "combined responsibility of patient and surgeon"

	Supportive role of other patients	Some patients had experience of meeting other patients before their surgery, and they felt that this was very useful for managing expectations and relieving anxiety, particularly in the context of meeting a patient with a stoma before their own surgery which was likely to result in a stoma. Patients thought that having a patient 'buddy' before surgery would be very useful for some. They also thought that offering the physical activity or psychological support aspects of prehab in a group setting could offer further support to patients.	"speaking with other patients offers so much support"
	Importance of involving family	Participants expressed it is important to include the patients' family in the prehab and surgery processes. Keeping the family informed could ease the psychological burden on the patient, and it may also offer them extra support through the prehab process.	"family need to know; they need to be told"
What outcomes should be measured to assess the prehabilitation programme?	Use of tests which are not absolute	Participants discussed different ways to measure physical activity and agreed that simpler methods such as Activpal or sit-to-stand were the best options. Many participants believed that CPET was a bad choice due to the "absoluteness" of it; they did not like the idea that some patients could be refused surgery due to their CPET score.	"feel sorry for those not getting [CPET] levels" "[don't like] the absoluteness of CPET" "Activpal [accelerometer] would be good"
	Length of stay unimportant	Participants recognised that length of stay is often an important outcome used by clinicians, but most agreed that this is an unimportant measure to them; patients felt that they would rather stay in hospital longer until they felt ready to leave.	"[being in hospital] feels protective" "complications more important than length of stay" "[when] I've reached targets that matter to me … then I'll go home"
	Patient-specific outcomes	Patients recognised that there were some differences in the outcomes that they each felt were important, it was therefore suggested that prehabilitation success could be measured on outcomes specific to each patient. For example, could measure the time taken to get back to baseline fitness, function, or quality of life. Some patients expressed that having personal goals to work towards would help to motivate them through the process.	"It takes ages to feel yourself again" "[patients with prehabilitation goals might] have more oomph" "targets that matter to me"

Appendix 3: Long list of items (n=118) and associated domains for Delphi.

Outcome/Standard Name	Domain no.	Outcome ID
Exercise	1	1
Nutrition	1	2
Psychological (emotional) support	1	3
Comprehensive geriatric assessment (for older; frail patients)	1	4
In secondary care (the hospital)	2	5
In primary care (the GP's practice)	2	6
In the community; for example at a local gym or community centre	2	7
Face-to face exercise supervision and advice	3	8
Remote exercise supervision and advice (e.g. by telephone or video-call)	3	9
One-to-one exercise supervision and advice	3	10
Group exercise supervision and advice	3	11
A personalised exercise programme specifically tailored to the individual	3	12
A standardised exercise programme designed for prehab but not specifically tailored to each individual	3	13
General exercise advice not specifically designed for prehab	3	14
Exercise that becomes progressively harder	3	15
High intensity/interval training	3	16
Endurance	3	17
Pulmonary physiotherapy exercises	3	18
Functional activity training	3	19
Cardiovascular /aerobic exercise	3	20
Resistance/weight training	3	21
Stretching/flexibility exercise	3	22
The exercise programme should last up to 2 weeks	3	23
The exercise programme should last 2-4 weeks	3	24
The exercise programme should last 4-6 weeks	3	25
The exercise programme should be in excess of 6 weeks	3	26
Face-to face nutritional advice	4	27
Remote nutritional advice (e.g. by telephone or video-call)	4	28
One-to-one nutritional advice	4	29
Group nutritional advice	4	30
A personalised nutritional advice programme specifically tailored to the individual	4	31
A standardised nutritional advice programme designed for prehab but not specifically tailored to the individual	4	32
General nutritional advice	4	33
The nutrition programme should last up to 2 weeks	4	34
The nutrition programme should last 2-4 weeks	4	35
The nutrition programme should last 4-6 weeks	4	36
The nutrition programme should be in excess of 6 weeks	4	37
Face-to face psychological support	5	38
Remote psychological support (e.g. by telephone or video-call)	5	39
One-to-one psychological support	5	40

Group psychological support	5	41
A personalised psychological support programme specifically tailored to the individual	5	42
A standardised psychological support programme designed for prehab but not specifically tailored to the individual	5	43
General advice on psychological support	5	44
Focus on anxiety reduction	5	45
Focus on body image including stoma concerns	5	46
Relaxation techniques e.g. breathing exercises; yoga	5	47
Mental preparedness and motivation	5	48
The psychological support should last up to 2 weeks	5	49
The psychological support should last 2-4 weeks	5	50
The psychological support should last 4-6 weeks	5	51
The psychological support should be in excess of 6 weeks	5	52
Cognitive assessments	6	53
Medication optimisation	6	54
Co-morbidity review	6	55
Falls advice	6	56
Advanced care planning	6	57
Patients undergoing surgery for benign conditions	7	58
Patients undergoing surgery for cancer	7	59
Patients undergoing laparoscopic (keyhole) surgery	7	60
Patients undergoing open surgery	7	61
Patients undergoing chemotherapy or radiotherapy prior to surgery	7	62
Patients having a stoma formed as part of surgery	7	63
Patients under 60 years of age	7	64
Patients aged 60-69	7	65
Patients aged 70-79	7	66
Patients aged 80-89	7	67
Patients aged 90 and over	7	68
Frail patients	7	69
High-risk' patients	7	70
Malnourished/underweight patients	7	71
Obese patients	7	72
Patients with recent or long-term mental illness	7	73
Surgeon	8	74
Anaesthetist	8	75
Specialist nurse	8	76
Oncologist (medical or clinical)	8	77
Exercise physiologist or sports scientist	8	78
Exercise oncologist	8	79
Sports medicine specialist	8	80
Exercise/activity specialist e.g. a personal trainer	8	81

Physiotherapist	8	82
Nutritionist/dietician	8	83
Geriatrician	8	84
Pharmacist	8	85
Psychologist	8	86
General practitioner (GP)	8	87
Other patients who are having/have had colorectal surgery	8	88
Daily or weekly Step count	9	89
CPET	9	90
Sit-to-stand	9	91
6 minute walk test	9	92
Respiratory/breathing measurements e.g. peak flow	9	93
Adherence to rehabilitation e.g. number of exercise sessions completed	9	94
Handgrip strength	9	95
Leg strength (e.g. leg/ quadriceps extension)	9	96
Percentage body fat	9	97
Weight change	9	98
Energy expenditure	9	99
Change in nutritional assessment	9	100
Fatigue	9	101
Anxiety	9	102
Depression	9	103
Stoma concerns	9	104
Stress	9	105
Sleep	9	106
Pain	9	107
Bowel function	9	108
Overall quality of life	9	109
Return to normal activities	9	110
Cognitive issues	9	111
Length of hospital stay	9	112
Complications	9	113
Length of critical care stay (High dependency unit or intensive care)	9	114
Discharge destination and support requirements	9	115
Inability to complete physical tests	9	116
Planned surgery does not go ahead	9	117
Prehabilitation stopped	9	118

- Domains: (1) components of prehabilitation; (2) setting of prehabilitation; (3) exercise/ physical activity; (4) nutrition; (5) psychological support; (6) comprehensive geriatric assessment (7); recipients; (8) delivery; (9) outcomes.