Community-based prehabilitation before elective major surgery: the PREP-WELL quality improvement project

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Title:
Community-based prehabilitation before elective major surgery: the PREP-WELL quality improvement project
Abstract:
Optimising health and well-being before elective major surgery via prehabilitation initiatives is important for good post-operative outcomes. In a busy tertiary centre in North East England, the lack of a formal prehabilitation service meant that opportunities were being missed to optimise patients for surgery. This quality improvement project aimed to implement and evaluate a community-based prehabilitation service for people awaiting elective major surgery: PREP-WELL. A multi-disciplinary, cross-sector team introduced PREP-WELL in January 2018. PREP-WELL provided comprehensive assessment and management of perioperative risk factors in the weeks before surgery. During a 12-month pilot, patients were referred from five surgical specialties at James Cook University Hospital. Data was collected on participant characteristics, behavioural and health outcomes, intervention acceptability and costs, and process-related factors. By December 2018, 159 referrals had been received, with 75 patients (47%) agreeing to participate. Most participants opted for a supervised programme (72%) and were awaiting vascular (43%) or orthopaedic (35%) surgery. Median programme duration was 8 weeks. The service was delivered as intended with participants providing positive feedback. Health-related quality of life (EQ5D utility) and functional capacity (6-minute walk distance) increased on average from service entry to exit, with mean (95% confidence interval) changes of 0.108 (-0.023 to 0.240) and 35 m (-5 to 76 m), respectively. Further increases in EQ5D utility were observed at 3 months post-surgery. Substantially more participants were achieving recommended physical activity levels at exit and 3 months post-surgery compared with at entry. The mean cost of the intervention £405 per patient; £52 per week. The service was successfully implemented within existing preoperative pathways. Most participants were very satisfied and improved their risk profile preoperatively. Funding has been obtained to support service development and expansion for at least 2 more years. During this period, alternative pathways will be developed to facilitate wider access and greater uptake.
Problem:
Several common modifiable risk factors such as anaemia, smoking, anxiety and low physical fitness have an adverse effect on outcomes after major surgery, including post-operative complication rates and recovery.(1) Prehabilitation services help patients to improve their ‘fitness for surgery’ but are not widely available in the UK National Health Service,(2) highlighting a need for improvement. To better understand the problem in the region we assessed the prevalence of behavioural risk factors (e.g. physical inactivity,

smoking, hazardous alcohol consumption) and attitudes to preoperative behavior change in 299 patients awaiting surgery.(3) More than three-quarters of patients (87.3%) had at least one risk factor, with 42.1% having two or more. Results also demonstrated high levels of patient motivation to change behaviour, however confidence levels to achieve this were significantly lower. Together, these findings further highlight the need for improvement using strategies which help patients access structured support in a timely manner.

South Tees Hospitals a large NHS Foundation Trust providing a range of specialist regional services to 1.5 million people in the Tees Valley and parts of Durham, North Yorkshire and Cumbria. James Cook University Hospital (JCUH) in Middlesbrough is the main facility offering tertiary referral services for a variety of surgical specialties including cardiothoracic, vascular, neurosurgery and orthopaedics. Here, the project team identified several barriers contributing to the inadequate recognition and management of perioperative risk factors, for example fragmented services, silo working across health sectors, and gaps in knowledge, skills and opportunity amongst healthcare professionals and patients. However, it was believed that systems and processes could be improved to benefit surgical patients. To this end, a regional cross health sector partnership between Public Health, Commissioners and Primary and Secondary Care was formed, and a Health Foundation innovation grant obtained (with matched funding), to design, implement and evaluate a community-based prehabilitation service called PREP-WELL.

Primary aim:
- To implement a multimodal, community-based prehabilitation service into preoperative care across multiple surgical pathways.

Secondary aims:
- To evaluate change in participant risk factors
- To evaluate patient engagement, adherence and experience
- To explore programme costs

Over a 12-month pilot, the service aimed to support up to 100 patients from five surgical specialties. This report describes the findings from this pilot.

Background:

Eight million surgical procedures are performed annually in the NHS at a cost of £11 billion.(4) Over 1.5 million of these are deemed ‘major’,(4) thereby placing significant physiological stress upon the patient. Despite ongoing improvements in perioperative care, clinical and functional outcomes remain suboptimal: 30-day mortality after major intra-abdominal surgery remains at 3.5-4%,(5, 6) with perioperative complications (e.g., heart problems and chest infections) at 15-40%.(7, 8) The body’s ability to withstand the physiological stress of major surgery is a key determinant of outcome, with better prepared patients (i.e., people with better physical fitness, nutritional status and mental health) experiencing a quicker and smoother recovery.(9-11) Even routine (uncomplicated) recovery is associated with increased fatigue and dependence, and reduced physical function and health-related quality of life (HRQoL) for 3-6 months.(12-14) Post-operative complications cause short- and long-term problems. In the short-term, they increase hospital length of stay and the risk of readmission.(7, 15) In the longer-term, complications can result in chronic health problems and dependency on NHS and social care services, inflating costs substantially.(4, 7)

Several common modifiable risk factors reduce ‘fitness for surgery’ resulting in delayed recovery and up to a 5-fold increased risk of complications. Examples [prevalence in

surgical patients] include: physical inactivity and low aerobic fitness [33-45%],(9) excessive alcohol consumption [23%],(16) smoking [24%],(17) obesity [33%](18) and poor mental health [unknown].(11) Close to 90% of surgical patients have at least one risk factor, with 'clustering' of ≥2 factors in >40%.(3) Socioeconomic deprivation is an important determinant of ill-health, with higher rates of risk factors and associated comorbid disease (e.g., cardiorespiratory disease, cancer and diabetes) fueling inequality in perioperative outcomes.(19, 20) Patients approaching major cancer surgery face unique challenges. A cancer diagnosis is often followed by chemoradiotherapy, which can significantly reduce physical and mental well-being;(21-23) transitioning patients from low to high perioperative risk, and thus compromising recovery and survival.(23, 24)

Identifying and managing perioperative risk factors in the weeks between diagnosis and treatment is therefore important for improved post-operative outcomes. The preoperative window may represent a 'teachable moment', a psychologically opportune time for lifestyle intervention.(1) Surgical patients may be motivated to make changes to support their recovery but lack the confidence to do so,(3) highlighting the need for structured support. Coordinated pre-operative optimisation strategies are termed 'prehabilitation',(1, 2, 23) which includes three stages: screening/assessment, individualised needs-based intervention(s), and post-treatment evaluation. Key intervention components include exercise training, nutritional support, psychological support, smoking cessation, alcohol reduction, and management of comorbid conditions (e.g. anaemia).(1, 2, 23) Other important intervention features include fast referral, easy access, and frequent support and contact from specially-trained healthcare professionals. Prehabilitation can produce meaningful improvements in perioperative risk factors within 2 weeks,(25) thereby facilitating patient readiness for surgery without undue delay. Subsequent benefits include a reduced risk of perioperative complications,(26) enhanced routine recovery with quicker return of functional independence and HRQoL,(27, 28) and health and social care financial savings.

Prehabilitation has been offered at many institutions internationally, demonstrating that it can be delivered in diverse range of settings. However, delivery has typically been in the context of a clinical trial, and variable according to specialty, patient risk profile, and the availability of resources and expertise. Ongoing clinical trials will help identify which prehabilitation delivery models produce the best outcomes, but quality improvement work is also needed to explore the feasibility of implementing services into routine perioperative care.

PREP-WELL was modelled on cardiac rehabilitation (CR) and may be viewed as delivering a modified CR model preoperatively. Indeed, strong parallels exist between prehabilitation and CR in terms of patient characteristics and intervention content. Both include entry and exit assessments and aim to support patients in improving multiple health behaviours such as exercise, smoking and diet. Audit data in the UK has demonstrated that CR services have been widely implemented, and can improve physical fitness, HRQoL and cardiovascular risk factors.(29) Sessions are typically group-based and offered two to three times per week.

Measurement:

The PREP-WELL prehabilitation service was introduced in South Tees Hospitals NHS Foundation Trust in January 2018. During a 12-month pilot phase, patients were referred to the service from five surgical specialties at JCUH: vascular, orthopaedics, upper gastrointestinal, urology, and colorectal. Follow-up data collection was completed by June 2019.

We undertook a mixed-methods prospective observational study of the new service. The measurement plan was designed to be practical to implement and to provide a comprehensive understanding of: (i) participant characteristics; (ii) changes in behavioural and health outcomes between service entry and exit; (iii) participant satisfaction; (iv) service costs; and (v) process-related factors.

Participants completed assessments at three main time points: (i) at service entry before prehabilitation; (ii) at service exit after prehabilitation (before surgery), and; (iii) at 3 months post-surgery. The service entry and exit assessments were conducted by the PREP-WELL project manager (EC), and involved obtaining measures of physical function (6-minute walk distance), health status (EQ-5D-3L), mental well-being (Hospital Anxiety and Depression scale, HADS) and lifestyle behaviour (self-reported physical activity status, smoking status and alcohol consumption). The entry assessments also included collection of demographic information and screening for comorbid conditions. The 3-month post-surgery follow-up involved a telephone-based re-assessment of the health status, mental well-being and lifestyle behaviour outcomes.

Participant satisfaction was assessed via interview or questionnaire. One-to-one telephone interviews were conducted with the first five participants after they had completed the exit assessment, with questions mostly focused on their experience of the service. All subsequent participants were sent a short feedback questionnaire to complete and return via post, which asked questions about what parts of the service were most and least useful, if they would recommend the service to other people in a similar situation, and their overall rating of the service (5-point scale from “Very poor” to “Excellent”). Several videos were also developed to capture patient stories.

A health economist (JG) calculated the costs of the service, which included the capital costs of intervention materials, staff time associated with delivery of the interventions and assessments, and overhead costs in terms of room rental. The costing analysis was conducted from an NHS and local authority provider perspective and all costs were based on 2018 prices.

Analyses were conducted using IBM SPSS Statistics Version 25 (IBM United Kingdom Limited, Hampshire, UK). Descriptive statistics (e.g. mean, SD, 95% confidence interval) were used to summarise participant characteristics, cost data, and changes in behavioural and health outcomes.

Design:

The improvement aim was to implement a community-based prehabilitation service for the management of perioperative risk factors in people awaiting elective major surgery. A schematic of the prehabilitation service improvement is shown in supplementary figure 1.

A core project team consisting of healthcare professionals (anaesthetists x4, surgeons x2, general practitioner, Directors of Public Health x2, information governance lead, surgical pathway manager, community well-being hub manager) and academics (exercise scientist, health economist, Professor of Cardiovascular Health) facilitated the development of a cross health sector partnership between Public Health, and Primary and Secondary Care. Subsequently, the project team was successful in obtaining funding for a 15-month pilot of the service through a Health Foundation innovation grant. Additional funding was secured from South Tees Hospitals NHS Foundation Trust, Public Health South Tees (the shared public health service of Middlesbrough Council and Redcar & Cleveland Borough Council), and NHS South Tees Clinical Commissioning Group.

The launch of the service was preceded by a 3-month preparation phase. Activities of this phase included: formation of a project steering committee; appointment of clinical champions (surgeons and anaesthetists) and a project manager (an experienced physiotherapist with a background in cardiac rehabilitation); confirmation of processes for data sharing and information governance; development of intervention materials, including a website (https://www.southtees.nhs.uk/services/prepwell-project/), assessment forms and information leaflets (copies available on request); training of intervention providers (i.e. exercise trainers and project manager) and referring clinicians; purchasing of equipment and consumables; development of a patient database, and; undertaking a site inspection to ensure safety of participants exercising in a non-clinical area.

The delivery model for PREP-WELL was based on UK cardiac rehabilitation services, and involved the following key features:

1) Early referral of patients who might benefit from prehabilitation
   - Clinical champions screen patients who had been listed for surgery for their suitability for PREP-WELL
   - Patients came from five surgical specialties: vascular, orthopaedics, upper gastrointestinal, urology, and colorectal
   - Screening forms sent to and reviewed by the PREP-WELL project manager
   - Informed consent for participation was taken
   - An introductory seminar for patients and their partners
   - Eligible patients invited for an entry assessment
2) Entry assessment
   - Patient attended a community well-being hub in Middlesbrough, UK (The Live Well Centre: https://thelivewellcentre.co.uk/)
   - Project manager conducted 75-minute entry assessment as described in previous section
   - Medical oversight provided to confirm suitability/safety of participation
   - Assessment data used to inform an individualised prehabilitation plan that was co-developed with the patient and signed off by clinical staff
3) Prehabilitation phase
   - Participants attended one or two exercise sessions per week at The Live Well Centre that were supervised by the Public Health South Tees Health Development delivery team and the project manager (a home-based alternative was available)
   - Access was also provided to other Live Well Centre lifestyle behaviour services, e.g. smoking cessation and alcohol reduction
   - Referrals could also be made to complementary local services where appropriate (e.g., weight management, psychological counselling)
   - Standard programme duration was 6-8 weeks, depending on patient and surgery related factors
   - Service was free-of-charge to patients
   - See Table 1 for further details of intervention components
4) Exit assessment
   - Patient attended The Live Well Centre
   - Project manager conducted a 30-minute exit assessment (described above)
5) Post-surgery follow-up
   - Project manager contacted the patient via telephone to conduct the 3-month post-surgery review (described above)

The original plan was to only include patients who were referred by one of the clinical champions and who were listed for surgery. However, the service subsequently received referrals from other sources (e.g. aortic aneurysm screening programme), and a decision

was also made to include three patients who were initially deemed too high risk for surgery at MDT evaluation. The latter change was to provide a gateway to surgery for those initially deemed as 'unfit'.

Patients or the public were not involved in the design, conduct, or reporting of this project.

Strategy:

The previous sections describe how the service was designed, implemented and evaluated.

Results:

Patient recruitment and flow through the service
Between January and December 2018, 159 referrals were made with 75 patients (47%) agreeing to participate. The most common reasons for non-participation were lack of interest (n=30), travel/transport difficulties (n=16), and surgery within 4 weeks (n=9). Surgeons and anaesthetists made the most referrals: 104 (65%) and 30 (19%), respectively, with the remaining referrals coming from specialist nurses (n=19), the regional aneurysm screening programme (n=5), and a GP (n=1). Patients were recruited from the five aforementioned specialties; however, most came from vascular (43%) and orthopaedics (35%). The mean time from referral to baseline assessment was 12 days (range = 0 to 62). The longer referral periods were usually for orthopaedic patients where no formal date for surgery had been set at the time of referral.

All 75 participants completed the entry assessment. Fifty-four (72%) participants chose to attend supervised sessions at the Live Well Centre, with the remaining 21 (28%) opting for a home-based programme. Few other results are presented for the home-based group due to high rates of missing data. Of the participants who attended supervised sessions, 27 (50%) completed the pre-operative exit assessment, and 33 (61%) completed the 3-month post-surgery assessment. For most cases, the reason for the assessment being missed was not documented. However, for seven participants the reason was because they left the service prematurely (no longer having surgery, n=3; too far to travel, n=2; family issues, n=1; unknown, n=1).

Participant characteristics
Participant characteristics at service entry are shown in Table 2. Participants often had multiple co-morbidities (range 0 to 6); common ones being hypertension (65%), arthritis (63%), and diabetes (26%). Eight (15%) participants had active malignancy, of whom six were undergoing chemo- or radio-therapy. Thirteen (24%) participants were anaemic, and two (4%) had obstructive sleep apnoea. Six (11%) participants were meeting the World Health Organization (WHO) recommendation for moderate-to-vigorous physical activity, and two (4%) were meeting the muscle strength recommendation. None were meeting both recommendations. Data on the type of operation are presented in the supplementary table 1.

Intervention details
Among the participants who attended supervised sessions (n=54), the median programme duration was 8 weeks (range 2.5 to 32). By specialty, the median programme duration was: vascular 7.5 weeks (2 to 24.5), orthopaedics 10 weeks (2.5 to 32), upper gastrointestinal 6 weeks (2.5 to 8), urology 6 weeks (4 to 12), colorectal 8 weeks. The median number of sessions attended was 8 (range = 0 to 34), and the mean number of participants attending each session was 5. Table 1 summarises the interventions that were

agreed with participants. All participants had exercise as an agreed intervention (17 [31%] of whom also undertook inspiratory muscle training); smoking cessation, 13%; alcohol reduction, 20%; anaemia treatment, 13%; psychological support, 13%.

Behavioural, fitness and health outcomes
Table 3 shows the behavioural, fitness and health outcome data for participants attending supervised sessions who completed all available assessments.

Between service entry and exit, one of four smokers reported quitting and five of 13 drinkers reported giving up alcohol. At entry, only four (17%) participants met the WHO guidelines for aerobic physical activity, with none meeting the guidelines for muscle-strengthening physical activity. Many of the participants reported being physically-active at follow-up, with 18 (75%) and 21 (87.5%) meeting the aerobic and muscle-strengthening guidelines respectively at service exit, and 15 (62.5%) and 7 (29%) meeting these guidelines at 3 months post-surgery. The number of participants drinking above recommended levels (≥14 units per week) dropped from 17% at entry to 4% at 3 months post-surgery.

Mean (95% confidence interval) values for systolic and diastolic blood pressure had decreased at service exit compared with entry: -6 mmHg (-12 to 0) and -4 mmHg (-8 to 0), respectively. The mean 6-minute walk distance had increased by 35 m (-5 to 76) at service exit, with 10 (56%) participants achieving an improvement greater than the minimum clinically important difference of 25 m.(29) There were also large improvements in the EQ-5D utility index scores between service entry to exit and service entry to 3 months post-surgery: 0.108 (-0.023 to 0.240) and 0.244 (0.049 to 0.438), respectively. Two fewer participants reported experiencing anxiety symptoms at service exit compared with entry (24% vs. 30%), with four fewer participants reporting depressive symptoms (6% vs. 18%).

Participant satisfaction
The five telephone interviews generated universally positive feedback about the service. Participants appreciated the peer support that developed within the group environment, saying that it made it more enjoyable and increased their motivation to keep attending. Perceived benefits appeared wide-ranging, including domains of attitude, fitness, weight, disease symptoms, and activities of daily living. Reasons for participating were varied and extended beyond improving fitness for surgery (e.g., “I was a bit down in myself and needed to get out”).

Seven later participants completed a feedback questionnaire. Six rated the service as ‘excellent’ and one rated it as ‘good’. All seven participants stated that they would recommend the service to others.

Several videos were developed to capture patient stories, which can be accessed via the following links:
- Why did you come to PREP-WELL? https://vimeo.com/323701838/6caf7c53d4
- What did you do in PREP-WELL? https://vimeo.com/323709390/f84d8fb9c7
- Would you recommend PREP-WELL to others? https://vimeo.com/323713515/e15ad54740

- Billy's story: https://vimeo.com/323740295/6409889c63

(N.B. Formal consent was obtained for these patient stories).

Surgical and post-operative outcomes

Forty-two (78%) participants had undergone surgery at the time of manuscript preparation. Following surgery, 62% of participants were admitted to a ward, 33% to a high dependency unit, and 5% to an intensive care unit. The median duration of hospital stay was 5 days (IQR 5) for vascular and 4 days (IQR 2) for orthopaedics. All participants were alive at 90 days post-surgery.

Unanticipated benefits

'Unfit' patients able to have surgery – Three patients with abdominal aortic aneurysm disease who were initially deemed unfit for surgery, but whom were referred to PREP-WELL, improved their fitness sufficiently for them to be later declared as fit for surgery.

Project endorsement by 'skeptical' surgeons – One of the vascular surgeons initially had significant reservations about the benefits of prehabilitation. They reluctantly agreed to occasionally send the odd patient to the service. One of their patients had multiple risk factors and had recently suffered a chest infection. A decision was made through MDT to defer surgery for 6 weeks and include the patient in PREP-WELL. The patient made significant improvements in fitness and underwent high-risk surgery uneventfully, leaving hospital in a shorter timeframe than average. This single case converted the surgeon who subsequently became a big advocate of the service.

Service costs

The total cost of the PREP-WELL pilot project was £101,000, with £75,000 secured from a Health Foundation Innovation grant, and £26,000 from stakeholder matched funding.

Intervention costs are summarised in supplementary table 2. Costs incorporated staff, equipment and overhead costs (e.g. room hire), and most of the cost incurred was due to staffing time. The mean (SD) total cost of the whole intervention was £404.86 (285) per participant. When broken down by specialty, costs varied according to number of sessions attended by participants, which likely related to operation waiting times; orthopaedics having the highest total cost (£475.92) and urology the lowest (£203.22). To account for this effect, a weekly total cost of £52.35 (27.30) per participant was estimated across all specialties.

Lessons and limitations:

The main aim of this project was to implement a community-based prehabilitation service, with a key focus of providing a sustainable solution to the longstanding problem of inadequate preparation of patients prior to surgery. To achieve this, a cross health sector partnership needed to be formed and a new service designed that would fit seamlessly into the existing preoperative pathway. To our knowledge, at the time of service development and implementation, PREP-WELL was the first community-based prehabilitation service of its kind in the UK. Embedding the service into routine pre-operative care across several surgical specialties was a key achievement, which was only made possible by having a highly engaged project management group and 'buy-in' from local clinicians and managers.

The majority of participants experienced improvements in health indicators and quality of life. Feedback has indicated that our community-based approach and efforts to de-medicalise the pathway supported patient autonomy and self-efficacy in changing their health behaviours. The participant interviews identified that the group environment and accessible location were key drivers of participation. Interviewees also stated that they were more likely to join an exercise facility after participating in PREP-WELL. Participants and staff recognised the social and peer-support benefits obtained. Spending time with others in a similar situation appeared to help in what can be a lonely and stressful time prior to a major operation. Another strong message was the value participants put in being able to 'take back control' of an aspect of their care. Many felt a lack of self-determination regarding medical decisions about their treatment and the ability to influence their own postoperative outcome, by getting 'fitter' for surgery, seemed a strong driver to engage.

The collaborative cross-sector approach focusing on 'prevention over cure' aligns well with wider NHS priorities. Our service aimed to capitalise on the 'teachable moment' of impending surgery in order to change health behaviours in both the short- and long-term. Several participants described positive changes to their lifestyles: nearly four times more participants were achieving recommended physical activity levels at 3 months after surgery compared with service entry. The ongoing uptake of regular physical activity and the reduction in alcohol consumption postoperatively seem to be a notable success of this project and will be of great interest to public health teams moving forward.

Another strength of the project was its 'Clinical Champion' scheme. These individuals provided an essential link between a busy multi-disciplinary clinical team and PREP-WELL, engaged colleagues, and helped ensure that the pilot was implemented effectively. Of note, more skeptical clinicians were convinced to begin referring their patients based on demonstrable success with individual patients, particularly those who were re-classified as 'fit for surgery' following successful engagement with the service.

In keeping with the cardiac rehabilitation model, we sought to embed assessment procedures that would permit service audit and subsequent learning and iterative improvement. In addition to the absence of a comparator control group, PREP-WELL is a complex intervention and as a result it is difficult to measure its clinical effectiveness. We were reliant on relatively lag measures of success. In retrospect, a more process-measure approach to our analysis would have supported more nimble adaptation of the service. Despite this, our quantitative and qualitative data obtained are encouraging.

Over 50% of patients referred to PREP-WELL declined to participate. Although uptake is comparable to cardiac rehabilitation in the UK,(29) it is critical to understand the reasons that patients decline to facilitate service adaptations accordingly. This could have been done by following-up reasons for non-engagement at the subsequent pre-operative assessment clinic by use of a patient questionnaire. Another way that improving our evaluation processes could have helped us is in addressing the reasons for non-attendance of PREP-WELL participants at assessment visits. Out of 54 participants taking part in the face-to-face intervention, only 27 (50%) attended the exit assessment pre-operatively, which affected the evaluation of the programme.

A further lesson from our project was the burden of data collection and dependence on one or two key people. Our project manager was responsible for undertaking the assessment of participants, overseeing the interventions and data collection. Alongside this, the project lead required unexpected leave due to ill health at a time when the data were being collated. Despite the team pulling together and working hard to minimise any disruption to the delivery of PREP-WELL, the data input and analysis was delayed. This

has underlined the need for dedicated data support of the service and the need for resilience in the system to handle unexpected disruption. We are currently in the process of designing a digital dashboard for PREP-WELL enabling real-time data entry and analysis. This will facilitate swifter detection of trends in referrals, uptake and adherence and enable more responsive adaptations to be made.

We acknowledge the importance of the entire perioperative pathway in determining surgical outcomes. At our centre, of the five specialties included in PREP-WELL, formal Enhanced Recovery After Surgery (ERAS) programmes are in place for orthopaedics, urology, colorectal and upper gastrointestinal. Vascular does not currently have a formal programme, although it does use elements of ERAS. Therefore, differences in ERAS protocols may have contributed to differences in outcomes (e.g. length of stay) between vascular and the other specialties.

We recognise that our local environment and opportunities, specifically the availability of a facility like the Live Well Centre, may limit wider generalisability. However, this reflected efficient use of local public health services that became available through effective cross-sector working. Our enquiries lead us to believe that many areas throughout the country do actually have similar facilities and with collaborative working between primary and secondary care and public health, access to these facilities and services may be possible. Equally, other key features of PREP-WELL are easily reproducible: the 'Clinical Champion' approach, seeking a community-based venue with co-located services for face-to-face intervention and offering a home-based option. In particular, our experience emphasised the value of a holistic approach to perioperative risk assessment and management, which can be achieved by engaging patients earlier in their pre-operative journey.

We believe that the costs of the project represent good value for money. Whilst a project of this nature can only ever deliver an estimate, we feel that, at just over £50 per patient per week, we have demonstrated that community-based programmes such as this are feasible.

Finally, this pilot project has underlined the need for a wider variety of prehabilitation options going forward, recognising that 'one size will not fit all'. A large proportion of patients (particularly patients undergoing orthopaedic surgery) were found to be lower risk (i.e., fewer risk factors) and could have exercised under supervision with less medical oversight. This is in contrast to those patients undergoing higher-risk procedures or with tighter surgical timeframes (e.g. cancer surgery). We aim to develop a 'low risk' PREP-WELL pathway for those patients in whom the current model may be too intensive. In addition, the popularity of the 'home-based' option highlights the demand for a further 'facilitated self-managed' alternative incorporating digital technology to facilitate monitoring and adherence.

Conclusion:

The project team identified limitations in the pre-operative care pathway, which motivated them to implement a prehabilitation service to improve patients' fitness for surgery. Participants were satisfied with the service and experienced improvements in perioperative risk factors before surgery. Key enablers of success included: securing project funding with matched stakeholder investment; achieving good patient engagement through effective supervision and peer support; effective multidisciplinary and cross health sector team working, and; locating the service in a central, easily accessible venue.

Learning from the pilot project will be used to refine and expand PREP-WELL over the next two years with the support of funding from Sport England and Macmillan Cancer

Support. Separate high- and low-risk pathways will be implemented including a digitally-enabled, remotely-facilitated option to widen access to the service, targeting 'prehabilitation for all'. Service expansion will be supported by the optimal use of regional facilities, staff and resources, and the development of a staff competency framework. A digital patient database and live 'dashboard' will also be developed to facilitate rapid service monitoring, audit and research.

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Contributorship statement

GT, JD, JG, DY and GD co-designed the project. EC was the project manager and aggregated the data. GT and JG analysed the data. GT took the lead in writing the manuscript. JD, DY and GD critically reviewed the manuscript and all authors contributed to the final version.

Table 1. Summary of prehabilitation interventions and what was offered to participants attending supervised sessions

Perioperative risk factor	Summary of intervention	Summary of what was offered to participants attending supervised sessions (n=54)
Physical inactivity/ low physical fitness	Supervised aerobic and resistance exercise training (one or two sessions per week) and unsupervised exercise and physical activity (as agreed with intervention facilitator). Patients with an increased risk of post-operative pulmonary complications also do inspiratory muscle training. See supplementary table 3 for further detail.	All 54 participants had exercise as an agreed intervention; 17 (31%) also undertook inspiratory muscle training
Smoking	Brief advice on smoking cessation from project manager with onward referral to Stop smoking services providing combined structured counselling and nicotine replacement therapy.	7 participants were smokers at baseline 2 agreed to referral, 2 self-referred, 3 attempted to stop independently
Underweight	Fortisip Compact Protein high energy (2.4 kcal/mL), high protein (18g/bottle) nutritional supplement; 2x 125 mL bottle each day (2.4kcal/ml)	2 underweight participants received nutritional supplements
Obese	Brief advice on diet from project manager emphasising healthy eating with onward referral to local specialist weight management service.	3 obese participants received brief advice from the project manager, 1 was referred to the weight management service
Frailty	Notification of general practitioner (GP) and secondary care teams by project manager	1 participant was frail at baseline - their GP and secondary care teams were notified
Excessive alcohol	Brief advice on alcohol reduction from project manager to reduce intake below 14 units weekly. Onward referral to specialist alcohol services if features of dependence present.	25 (46%) participants were alcohol drinkers at baseline 11 drinkers received brief advice from the project manager, 1 was referred to the alcohol reduction service
Anaemia	Rapid access to preoperative anaemia pathway (with provision of intravenous iron),or referral for management via GP dependent on severity and preoperative timeframes.	7 participants were anaemic at baseline 5 participants received intravenous iron via the pre-assessment pathway, 2 were referred to their GP
Obstructive sleep apnoea	Expedited home-based diagnostic sleep test to identify obstructive sleep apnoea following identification of increased risk via initial questionnaire screening	3 participants were deemed high-risk for obstructive sleep apnoea; following further evaluation, 1 initiated CPAP therapy
Anxiety/Depression	Referral for mindfulness training or psychological counselling	9 participants had elevated anxiety *or* depression scores (HADS >7) at baseline, 6 had raised anxiety *and* depression scores

	5 participants were offered mindfulness training, 1 was referred to counselling

Table 2. Participant characteristics at service entry

	Supervised programme (n=54)	Supervised programme and completed exit assessment (n=27)	Home-based programme (n=21)
Age, years	69 (10)	67 (12)	68 (8)
Range	42-87	42-84	51-82
Male sex, n (%)	38 (70)	21 (78)	14 (67)
Ethnicity, n (%)			
White British	53 (98)	27 (100)	21(100)
Asian	1 (2)	0 (0)	0(0)
Marital status, n (%)			
Married	33 (61)	13 (48)	14 (66)
Other*	21 (39)	14 (52)	7 (33)
Body mass index, kg/m^2	29.4 (5.3)	30.3 (5.2)	28.5 (3.8)
>35, n (%)	4 (7)	4 (15)	1 (5)
<20, n (%)	2 (4)	1 (4)	0 (0)
Co-morbidities, n (%)			
Ischaemic heart disease	10 (19)	5 (19)	3 (14)
Angina	5 (9)	3 (11)	0 (0)
Heart failure	2 (4)	0 (0)	0 (0)
Hypertension	35 (65)	17 (63)	10 (48)
Arrhythmia	8 (15)	4 (15)	4 (19)
COPD	7 (13)	2 (7)	1 (5)
Asthma	11 (20)	4 (15)	2 (10)
Arthritis	34 (63)	17 (63)	11 (52)
Diabetes	14 (26)	5 (19)	2 (10)
Active malignancy	8 (15)	3 (11)	1 (5)
Anaemia	13 (24)	4 (15)	2 (10)
Frailty[†]	2 (4)	0 (0)	1 (5)
Obstructive sleep apnoea	2 (4)	1 (4)	0 (0)
Cognitive impairment[‡]	20 (37)	10 (37)	7 (33)
Surgical specialty, n (%)			
Vascular	23 (43)	12 (44)	9 (43)
Orthopaedics	20 (37)	10 (37)	6 (29)
Upper gastrointestinal	6 (11)	3 (11)	2 (10)
Urology	4 (7)	1 (4)	2 (10)
Colorectal	1 (2)	1 (4)	2 (10)
Physically active[§], n (%)			
Aerobic	6 (11)	4 (15)	4 (19)
Muscle-strengthening	2 (4)	0 (0)	3 (14)
Aerobic & muscle	0 (0)	0 (0)	0 (0)
Smoking status, n (%)			
Current	8 (15)	4 (15)	0 (0)
Previous	15 (28)	8 (30)	5 (23)
Never	31 (57)	15 (56)	16 (77)
Alcohol consumption, n (%)			
0 units/week	29 (54)	12 (44)	8 (38)
0-14 units/week	14 (26)	10 (37)	8 (38)
>14 units/week	11 (20)	5 (19)	5 (24)

Data are presented as mean (SD) unless otherwise stated.

*Includes single, widowed, divorced, and cohabiting

[†]Defined as a Clinical Frailty Scale score of ≥5

[‡]Defined as a mini-cog score of ≤4

[§]Defined as meeting WHO guidelines for physical activity(30)

Table 3. Risk factor, functional capacity, EQ5D and HADS data for participants attending supervised sessions who completed all available assessments

	n	Service entry	Service exit pre-surgery	3 months post-surgery	Mean difference (95% CI) Entry to exit	Mean difference (95% CI) Exit to post-surgery follow-up
Non-smokers, n (%)	24	20 (83)	21 (87.5)	20 (83)	N/A	N/A
Alcohol consumption, n (%)	23					
0 units/week		10 (43)	15 (65)	13 (57)	N/A	N/A
≤14 units/week		19 (83)	20 (87)	22 (96)	N/A	N/A
Physically active[§]	24					
Aerobic, n (%)		4 (17)	18 (75)	15 (62.5)	N/A	N/A
Muscle-strengthening, n (%)		0 (0)	21 (87.5)	7 (29)	N/A	N/A
Aerobic & muscle, n (%)		0 (0)	18 (75)	7 (29)	N/A	N/A
Body mass index (kg/m^2)	24	30.3 (5.2)	30.0 (5.2)	N/A	-0.3 (-0.8 to 0.2)	N/A
Range 20-35, n (%)		20 (83)	21 (87.5)	N/A	N/A	N/A
Systolic blood pressure (mmHg)	20	147 (18)	142 (17)	N/A	-6 (-12 to 0)	N/A
Diastolic blood pressure (mmHg)	20	87 (8)	83 (7)	N/A	-4 (-8 to 0)	N/A
6-minute walk distance (m)	18	444 (177)	479 (155)	N/A	35 (-5 to 76)	N/A
EQ-5D utility index*	25	0.535 (0.375)	0.643 (0.338)	0.778 (0.299)	0.108 (-0.023 to 0.240)	0.244 (0.049 to 0.438)
EQ-VAS[†]	25	68 (16)	68 (17)	76 (19)	0 (-4 to 5)	8 (1 to 16)
HADS-A[‡]	33					
Score, mean (SD)		5.5 (4.8)	5.4 (5.1)	4.4 (5.0)	-0.1 (-1.8 to 1.5)	-1.0 (-2.3 to 0.2)
Any anxiety symptoms (score 8–21), n (%)		10 (30)	8 (24)	9 (27)	N/A	N/A
Anxiety (score 11–21), n (%)		6 (18)	5 (15)	6 (18)	N/A	N/A
HADS-D[‡]	33					
Score, mean (SD)		4.6 (4.3)	3.8 (3.9)	2.5 (3.7)	-0.8 (-1.9 to 0.3)	-1.3 (-2.1 to -0.5)
Any depressive symptoms (score 8–21), n (%)		6 (18)	2 (6)	1 (3)	N/A	N/A
Depression (score 11–21), n (%)		3 (9)	1 (3)	1 (3)	N/A	N/A

Data are presented as mean (SD) unless otherwise stated

CI, confidence interval; EQ-VAS, EuroQol Visual Analogue Scale; HADS-A Hospital Anxiety and Depression Scale – Anxiety subscale score; HADS-D, Hospital Anxiety and Depression Scale - Depression subscale score; N/A, not applicable; SD, standard deviation.

*EQ-5D utility scores range from -0.594 to 1, with higher scores indicating a better health status

[†]EQ-VAS scores range from 0 to 100, with higher scores indicating a better health status

[‡]HADS-A and HADS-D scores range from 0 to 21, with higher scores indicating more severe symptoms

[§]Defined as meeting WHO guidelines for physical activity(30)

Supplementary table 1. Specialty and type of operation

Specialty	Operation	Supervised programme (n=54)	Supervised programme and completed exit assessments (n=27)
Vascular	EVAR	14	6
	Open AAA repair	5	5
	AAA repair (unspecified)	1	0
	Arterial bypass graft	3	1
Orthopaedics	Total Knee Replacement	15	8
	Total Hip Replacement	5	2
Upper GI	Oesophagectomy	5	3
	Gastrectomy	1	0
Urology	Cystectomy	3	1
	Cystectomy/Iliostomy	1	0
Colorectal	Hartmann's	1	1

AAA, abdominal aortic aneurysm; EVAR, endovascular aneurysm repair; GI, gastrointestinal

Supplementary table 2. Costs of the supervised sessions and the whole intervention

Description	n	Number of supervised sessions/participant	Cost of all supervised sessions/participant	Cost of whole intervention/participant	Weekly cost of whole intervention/participant
Total	43	9.5 (8.6)	£312.65 (281.01)	£404.86 (285)	£52.35 (27.30)
By Speciality					
Colorectal	1	11	£360.69	£454.75	£56.84
Orthopaedics	14	11.9 (9.7)	£391.14 (318.29)	£475.92 (324.59)	£48.47 (29.71)
Upper GI	6	4.3 (4.3)	£142.09 (141.67)	£245.29 (156.08)	£45.11 (24.64)
Urology	4	4 (5.5)	£131.16 (179.60)	£203.22 (179.60)	£29.39 (33.41)
Vascular	18	10.6 (8.7)	£346.12 (285.68)	£444.81 (287.58)	£57.74 (27.27)

Data are mean (SD) unless stated.

Supplementary table 3. Expanded description of the exercise component of the PREP-WELL prehabilitation service

Why?	Structured exercise training prior to surgery has the potential to improve physical function and cardiometabolic health, leading to better post-surgical recovery.
What materials?	Aerobic exercise: cycle ergometers, treadmills, cross trainers, rowing ergometers, platforms for stepping Resistance exercise: TheraBands elastic bands of varying thickness, dumbbells, fixed resistance machines Inspiratory muscle training: POWERbreathe Medic Classic Other: heart rate monitors, pedometers, information leaflets
What procedures?	Participants were invited to attend two 90-minute, supervised, group-based exercise sessions per week for at least 6 weeks preoperatively. Home-based exercise training was also encouraged on most days. Individuals with an increased risk of post-operative pulmonary complications (identified using the ARISCAT tool) also performed inspiratory muscle training. Typical format of supervised exercise sessions: - Warm up (10 minutes) - Group-based circuit training involving aerobic and resistance exercises (30-50 minutes) - Cool down / flexibility exercises (10 minutes) - Social time (20-30 minutes) Exercises were selected and tailored to suit individual capacity for physical function and their lifestyle. The intensity of exercise was guided by the use of Borg's CR10 scale, with participants generally encouraged to exercise at an exertion level of 2-4 (somewhat hard). A maximum patient-to-instructor ratio of 10:2 was used to ensure adequate supervision. Inspiratory muscle training (IMT): Participants were encouraged to complete two sessions of IMT per day for 5-7 days per week. Each session comprised 36 breaths at 30-50% maximal inspiratory pressure. The 36 breaths were split into 6 sets of 6 breaths, with a decreasing recovery time between each set (60 s, 45 s, 30 s, 15 s, 5 s). The resistance on the IMT device was adjusted to maintain a 'hard' level of exertion in each session. Home-based exercise training: Participants were given a pedometer and encouraged to accumulate at least 7500 steps per day, ideally including at least 30 minutes of brisk walking. People who did not like walking, or who had difficulty walking, were able to choose a different mode of exercise. The target intensity was moderate-to-hard, which was self-regulated using the Borg CR10 RPE scale. Participants were also given a set of three TheraBands of varying resistance and a training plan lasting 20-30 minutes. The plan included a combination of TheraBand and body-weight exercises targeting all major muscle groups, with each exercise performed for 1-3 sets of 10-15 repetitions to the point of moderate muscle fatigue.
Who provided?	The exercise sessions were supervised by the project manager who had a background in cardiac rehabilitation and two members of the Public Health South Tees Health Development delivery team who were trained and experienced in delivering exercise therapy to clinical populations.
Where?	Supervised sessions were held at The Live Well Centre, Middlesbrough (http://www.thelivewellcentre.co.uk/)
Fidelity monitoring?	For supervised sessions, attendance registers were maintained and heart rate and perceived exertion ratings recorded. For home-based sessions, participants were asked to maintain an exercise diary.

Supplementary figure 1. Schematic of prehabilitation service improvement