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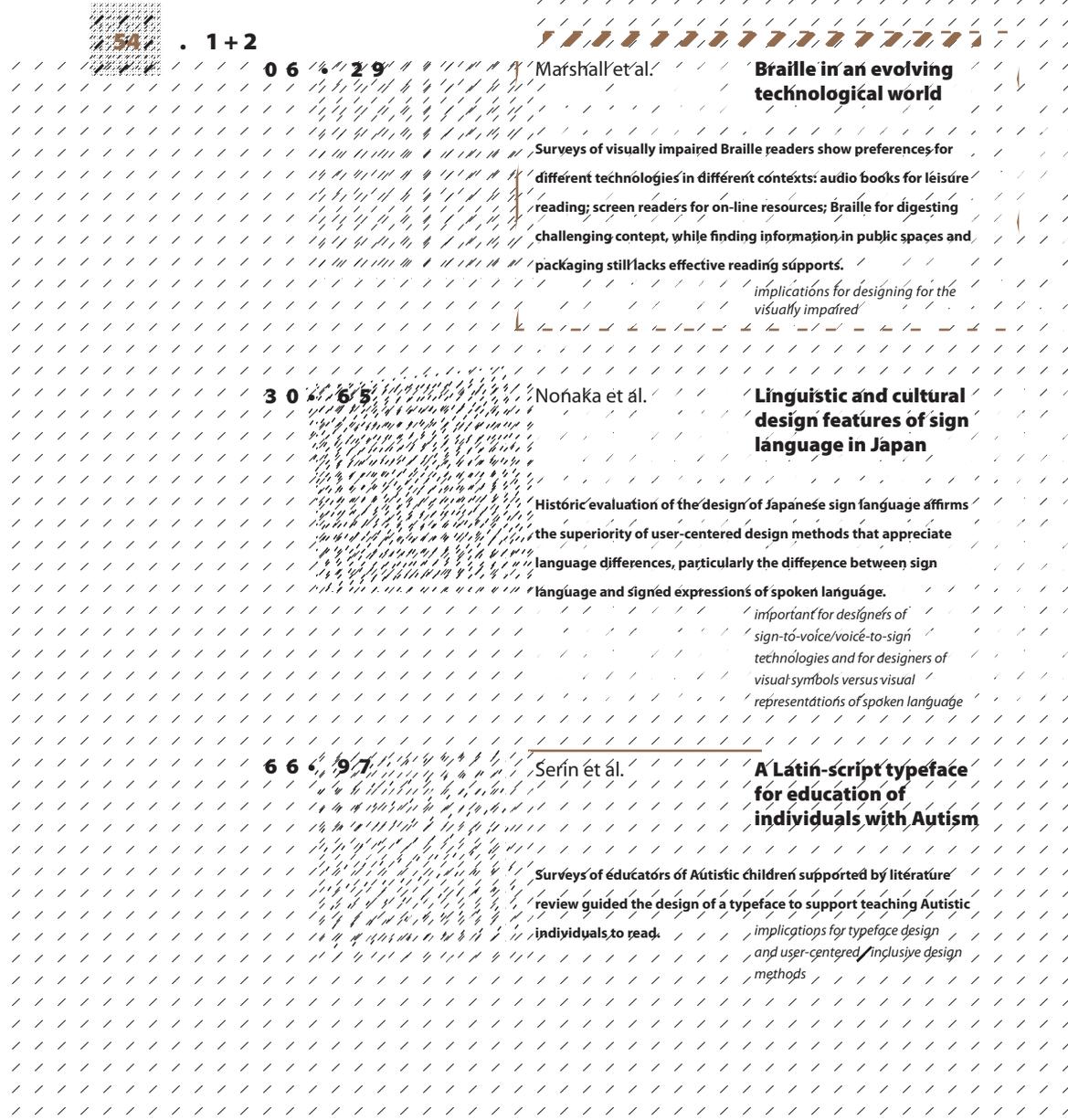*implications for type design and design's role in culture/technology conflicts*

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Before there was reading there was seeing.

People navigate the world and probe life's meaning through visible language. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that visual design is a means of communication that must be defined and explored on its own terms. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

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Visible Language

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Enhancing Bowel Cancer Surgery Recovery through Information Design:

The impact of combining design and cognitive principles with user-centered research methods, on patient understanding of surgery recovery information.

Maria dos Santos Lonsdale

Stephanie Sciberras

Hyejin Ha

Stephen J Chapman

Bowel surgery is the most common treatment for numerous bowel diseases including cancer. The provision of information before and after bowel surgery is an important element of recovery. Pre-operative education assists in the psychological preparation for surgery, which has been shown to have a positive impact on patient satisfaction, pain management, and the duration of hospital stay. Traditionally, information is provided before surgery and delivered in text heavy written format, which presents a number of challenges, such as patients feeling overwhelmed, especially when diagnoses of cancer and plans for major surgery are discussed concurrently. Previous evidence also shows patients desire to be pro-actively involved in their recovery. Unfortunately, the development of new education interventions uncommonly involves patients and other information specialists in their design. To tackle this problem, a mixed-methods user-centered design approach was conducted to redesign an existing patient information booklet in order to meet patient needs and improve communication among patients and medical staff. For example, among other methods, a 'within co-design' approach was used to identify stakeholder needs. Several usability tests and iterations were conducted throughout the design development to create a more visualized design format that follows research-based cognitive and design principles. Empirical testing was then conducted to evaluate and validate the final booklet design, collecting both qualitative and quantitative data. Results show significant differences in performance and users' preference between text dense information and a combination of text and visualized information. This in-depth research focusing on the booklet was then followed by the development of companion outputs (website and environmental infographics) through the same mixed-methods user-centered design approach. All in all, this study provides significant evidence and important guidelines on how to effectively communicate bowel surgery recovery information to patients, in order to increase their understanding and active role in their recovery, as well as minimize their uncertainties and anxiety. Although focusing on a specific scenario, these findings are also widely applicable to many forms of healthcare information.

1. Introduction

1.1. Background and context

Bowel cancer is the third most common cancer in men and the second most common cancer in women, with over 1.8 million new cases in 2018 (World Cancer Research Fund, 2019). Its most common treatment is bowel surgery (Cancer Research UK, 2019; Cancer.net, 2018), which requires a lengthy recovery and causes significant distress and changes to a patient's lifestyle (Nugent et al., 1999).

The provision of information before and after bowel surgery is an important element of recovery. Pre-operative education assists in the psychological preparation for surgery, which has been shown to have a positive impact on patient satisfaction, pain management, and the duration of hospital stay (Johnson and Vogele, 1993; Spaldin, 2004). In the UK, for example, its importance is highlighted by national clinical guidelines (ERAS – Enhanced Recovery After Surgery guidelines) provided by the NHS (National Health Service), which stipulate that patients should be adequately educated about their planned surgery (Gustafsson, 2019). Traditionally, information is provided before surgery and delivered orally and in written format by healthcare professionals (Davidson and Mills, 2005; McMullan, 2006). This presents a number of challenges, such as volume of information, particularly when patients are undergoing complex surgical treatments, and timing of information during sensitive medical consultations. Patients may feel overwhelmed, especially if diagnoses of cancer and plans for major surgery are discussed concurrently (Chelf et al., 2002). Moreover, due to the negative effects psychological distress has on cognitive processing (Tetlan and Marschalek, 2016), the retention of instruction by patients in such precarious and vulnerable situations is impaired (Houts et al., 2006; Wilson and Wolf, 2009).

As a result, supportive information materials are highly necessary to further support, educate and inform the patients. In a study by Gustafsson et al. (2012), patient information booklets were found to be highly beneficial as a supportive and accessible self-educational tool. Information booklets enable patients to revisit and reference the information discussed during their consultations, at their own pace and as many times as needed (Thomas et al. 2000). However, current NHS patient information materials are inconsistent in presentation and information, text heavy, and written at a higher literacy level than that of the UK's adult population (Safeer and Keenan, 2005; McCartney, 2013; National Literacy Trust, 2017). Additionally, patient-related factors such as literacy level, age, and age-related disabilities tend to be disregarded when printed or online information is designed (Choi, 2011; Pieper et al., 2006). Regarding the information provided by the ERAS programme, patient feedback reinforces the need for improvement and identifies similar problems such as: information being too repetitive, text heavy, insufficient and difficult to understand (Alawadi et al., 2016; Herbert et al., 2017). All these difficulties are identified as factors preventing patients from actively participating in their recovery (Houts et al., 2006; Peregrin, 2010; Keinki et al., 2018; Samuelsson et al., 2018). As a possible solution to overcome these many difficulties, some studies have shown evidence that using text and visualization together can improve patient accessibility and understanding of information as well as recall of information (Jefford et al., 2005; Bol et al., 2015; Hill et al., 2016).

Other limited evidence has explored novel ways of providing education to optimise this process. This includes multimedia interventions provided on smartphones and tablets, formal pre-operative seminars with recovery specialist nurses, and websites used to reinforce existing information provided at the hospital (Al-Bahrani and Plusa, 2004; Sajid et al., 2008; Kim et al., 2018; Klaiber et al., 2018; Pecorelli et al., 2018). However, some argue that relevant and accurate health information on the web is limited and time consuming to locate (e.g. Al-Bahrani and Plusa, 2004). Moreover, in a study by Bolle et al. (2016), health websites have also been found to have multiple usability issues that impede low digital literate users (like the elderly) to locate the information they need. These include: lack of text legibility (text is too small and without sufficient background contrast); complex navigation menus; small clickable targets; and unrelated imagery used solely for decoration.

But, all in all, both mediums (booklet and website) have great potential and are found to encourage patients to be involved in any decision-making, empower patients to be active collaborators in their recovery, and reduce procedure anxiety and morbidity (Rutten et al. 2004; Marteau et al., 1996; Paul et al., 2003, Luck et al. 1999). Our argument is that they need to be designed effectively by following research-based information design principles, cognitive principles, as well as designed with the user and for the user. The latter is further supported by studies showing that patients desire to be pro-actively involved in their recovery and that the provision of information should be multimodal, comprehensive, and done at various time points throughout the patient treatment pathway (Poland et al., 2017). Unfortunately, the development of new education interventions uncommonly involves patients and other information specialists in their design. It is not surprising, therefore, that the provision of information before and after surgery remains as an unmet challenge. This is evident, for example, in the Enhanced Recovery After Surgery programme. ERAS is a concept of teamwork based on coordinated actions between healthcare professionals and patients. Therefore, it is important for patients to be empowered and actively participate in their recovery (Aasa et al., 2013; Bernard and Foss, 2014; Herbert et al., 2017; Sibbern et al., 2017). Part of that role is to be given the opportunity to co-design the ERAS information that is presented to them (Short et al., 2016; Keinki et al., 2018) and make sure that the information they receive meets their needs and expectations. The ERAS information should be patient-centred and, according to Sibbern et al. (2017), be based on patient perception and understanding of information.

1.2. Information processing

As discussed by Tetlan and Marschalek (2016), poorly designed information is harder to process and requires more attention and mental effort from users in order to do so. The same argument has been put forward by Wilson and Wolf (2009) in relation to health materials. To fully understand how and why the design of information may affect understanding, it is important to first understand how humans process visual and written information and where the application of effective design principles can make a difference.

As explained in existing studies (e.g. Few, 2012; Lonsdale and Lonsdale, 2019), humans process information through three types of memory: iconic memory, working memory, and long-term memory. In the iconic memory information is processed very quickly and unconsciously; it is more like pre-attentive information processing. To grab the attention of the user, features like color, form and location of elements should be used. In a second stage, information moves to the working memory, which has limited storage and is temporary. Because of that,

information that is considered useful is selected and combined it into meaningful chunks. Therefore, to help the user process complex and large amounts of information, information should be presented in chunks, as this will reduce cognitive load. Moreover, although storage capacity in the working memory is limited to only three to four, maximum five, chunks of information, each chunk can contain a good amount of information if designed effectively and in a coherent and consistent manner (Cowan, 2010; Patterson et al., 2014; Pissierssens, 2017; Lonsdale and Lonsdale, 2019). Successful chunking can be achieved by using com-mon features between sections of information (e.g. color and shape) and/or by following the Gestalt principles of perception, as these represent the mechanics by which humans perceive and recognize patterns (Lipton, 2007; Patterson et al., 2014). This is also where visualization can be very helpful, as visualization can communicate a large amount of information that is perceived all at once. Failing to design complex and large amounts of information effectively will result in cognitive overload, with the user feeling overwhelmed and disengaged from the information, thus hindering user learning and making cognitive processing ineffective (Sweller and Chandler, 1994).

In the last stage of memory, humans decide what information to keep and send it in chunks to the long-term memory for storage, which is also where the ability to recognize visuals takes place. This whole process of decoding and selecting relevant units of information hap-pens within mere seconds. In summary, the amount of knowledge assimilated by the brain is determined by how long it can remain attentive and by how hard the working memory needs to work to process the information at hand – mental effort is known as the cognitive load and found to be directly affected by how information is presented and designed (Sweller and Chandler, 1994; Wilson and Wolf, 2009; Tetlan and Marschalek, 2016). Therefore, information needs to be designed as effectively as possible to make sure that during the iconic memory and working memory it is perceived and processed adequately.

In some cases, one way by which information processing can be facilitated and improved, is by presenting it in both written and visual formats (Wilson and Wolf, 2009). By doing so, cognitive load is reduced, i.e. the mental effort required to learn the information is reduced. As a consequence, users can focus more on the content than trying to figure out the way in-formation is presented (Lyra, et al., 2016). This is further supported by dual code theory, which notes that humans process and learn information better when "they receive combined verbal and visual messages" (Pettersson, 2015, p.233). In fact, visualization such as pictograms, il-lustrations, diagrams and infographics have been proven to play a major role in simplifying complex information. It is done by presenting it in a more concise, accessible and engaging manner, thus improving its retention and recall (Mansoor and Dowse, 2003; Houts et al., 2006; Osborne, 2006; Barros et al., 2014; Royal and Erdmann, 2018). Moreover, the human eye also has a larger viewing capacity for shapes than text, resulting in the eye being usually drawn to an image before text (Tetlan and Marschalek, 2016).

1 . 3 .   C a s e   s t u d y

This study was conducted in collaboration with the John Goligher Colorectal Surgery Unit (JGCSU) of the Leeds Teaching Hospital in the UK. Their 'Colorectal Enhanced Recovery Programme - Patient information Booklet' was used as a live case study and updated with a new design. The existing booklet was produced in-house by the colorectal specialist nurses in 2015, following the NHS Enhanced Recovery After Surgery programme. The redesigned

version of this booklet developed in the present study, was then used as the foundation for the development of two other companion and/or supplementary outputs, capable of strengthening the support given to patients during their surgery recovery: a website and environmental infographics. These two choices emerged from the primary research described next in Section 2.

1 . 4 .   A i m s ,   o b j e c t i v e s   a n d   h y p o t h e s i s

This study aims to improve the understanding and accessibility of Enhanced Recovery Infor-mation for bowel cancer patients through the combined use of research-based information design principles, cognitive principles, and user-centered research methods. To help achieve this aim, the objectives are to:

_____ Survey existing bowel surgery recovery booklets in and outside the UK to iden-tify good and bad practice for both content structure and design problems.

_____ Identify problems and user needs by conducting a mixed methods research approach and involving all relevant parties in an initial stage of the study. This includes all stakeholders who use the existing JGCSU booklet to communi-cate during the surgery recovery process: patients (primary end-users), and nurses and surgeons (secondary end-users, i.e. people in direct contact with a primary end-user).

_____ Redesign the existing JGCSU booklet based on information design and cogni-tive principles from the literature and findings from the initial stage of the study.

_____ Conduct various stages of usability testing and iteration with the primary end-user (former patients/representative users) during the design development stage, and continue to involve nurses and surgeons in the process as secondary end-users.

_____ Ascertain the validity of the redesigned booklet through experimental compari-son between existing and new design measuring user performance (speed and accuracy of finding information) and collecting user opinion.

_____ Adapt the booklet information to a website and environmental infographics taking into consideration research-based design principles and conducting test-ing and iteration with the primary end-user (while continuing to involve nurses and surgeons as secondary end-users).

Based on previous studies and findings, the following hypothesis is put forward: Bowel surgery recovery information combining text and visualization, designed according to research-based information design principles, cognitive principles, and applying user-cen-tered research methods that involve the user in all stages of the design and research process, facilitates access to information, enhances patient understanding, and is favored by users.

2 . Identification of problems and needs

2 . 1 .   M e t h o d o l o g y   a t   a   g l a n c e

Since the quantity and depth of information needed by patients is subject to an individual's coping mechanism, as well as type and severity of disease (Marteau et al., 1996), it was es-sential for the new information package to be user-centered and designed around needs and

expectations. We specifically chose the more general term user-centered and not patient-centered because, to identify valid and reliable design solutions, we involved all stakeholders at all stages of the research and design development. During patient surgery recovery there is a three-way communication channel between nurses, surgeons and patients, where all need to communicate effectively with each other. Therefore, our aim was to develop a design solution that was inclusive of all these three stakeholders and capable of enhancing the communication between them.

Towards this end, a first stage of research was conducted using a number of quantitative and qualitative research methods in order to: a) identify stakeholder needs; b) identify issues with the existing Colorectal Enhanced recovery booklet; and c) identify the most appropriate design features (typography, visualization, layout and color) to use in the redesign. Table 1 shows the research methodology at a glance, which will then be discussed in more detail in the sections to follow, including the findings from each method.

2.2. Design problems

2.2.1. Online questionnaire

An online questionnaire was conducted to identify problems with the booklet currently being used at JGCSU, and obtain suggestions for its content and redesign. Participants (10 in total) were recruited from all over the UK via the Surgical MedTech Co-operative of the Leeds Teaching Hospital, and were former bowel surgery patients. The first section of the questionnaire focused on the content of the booklet, and the second section focused on design features.

In terms of content, 70% of participants considered the existing booklet easy to read, although some also pointed out things like: "Far too wordy"; "It is easy to understand up to a point, but there are a lot of long sentences and some complex language"; "I found the content a little bit disjointed". What was very interesting, however, was the fact that, when asked how the JGCSU booklet compares to the one they received form their hospital for their bowel surgery, 80% of participants considered the JGCSU booklet to be better, 10% similar, and 10% worse. This strengthens the researchers' position of the need to improve patient information overall. When asked about the type of booklet, i.e. a detailed booklet with all the information, or a more concise booklet with links to a companion website with further information, there was a fifty-fifty split. In addition, participants were very good at giving clear and detailed suggestions for information to be included on 'before surgery' and 'after surgery'.

In terms of design features, selecting from a series of examples provided, participants preferred: A5 size for the booklet (90%); cool colors – blue, green and purple (participants could select more than one color and all these three colors were selected an equal amount of times, i.e. 5 times); sans serif font (90%); checklists to remind of key points (90%); pictograms (selected 7 times) and infographics (selected 6 times) as the best visualization format, with colored and outlined being the most popular style (selected 4 times). For a companion output, the majority of participants chose a website (selected 9 times), with the second most popular choice being a motion graphics video (selected 3 times), followed by environmental infographics (selected 2 times). Participants thought that the website should include more information than the booklet (90%). For the environmental infographics, participants sug-

gested the following locations in order of preference: Hospital room – to see information while recovering (selected 6 times); Pre-assessment clinic room – to see information while counselling with the specialist nurse (selected 5 times); Hospital corridor – to see information when starting to move around during recovery (selected 4 times); and only one participant selected the statement that it would not be useful to have environmental infographics as it will not be possible to take any information in at the time.

TABLE 1:

Research methods used in the first stage of the study focusing on

METHODOLOGY AT A GLANCE			
	Sample	Procedure	Test material
DESIGN PROBLEMS			
Online questionnaire	• 10 former patients (7F + 3M) • 40-70 age group	• Section 1: content related questions • Section 2: design related questions	• Google form questionnaire • Links to pdf of exisitng JGCSU booklet • Visual examples
Usability test 1	• 5 participants (1F + 4 M) • 51-73 years old • Average age: 64	• Section 1: performance task to find specific information • Section 2: opinion about design	• Paper task questionnaire • Google form interview questions • Existing JGCSU booklet • Competitor booklets
Visual survey	• 54 booklets • Written in English • From around the world	• Analysis of information content • Analysis of design features: typography, color, layout, visualization, etc.	• N/A
USER NEEDS			
Interview w/ surgeon	• 1 surgeon	• Questions about ERAS programme (Enhanced Recovery After Surgery)	• Interview script
Co-design w/ nurses	• 2 specialist nurse • 1 ward nurse	• Information card sorting • Review and analysis of existing JGCSU booklet • Analysis of competitor booklets • Identification of possible visualized info in original booklet spreads	• 110 topic cards • Existing JGCSU booklet • Competitor booklets (UK, US and Australia) • Visualization stickers
Co-design w/ surgeons	• 3 surgeons	• Same as co-design with nurses	• Same as co-design with nurses
Co-design w/ former patients	• 4 former patients (3F + 1M)	• Same as co-design with nurses • Re-design of existing JGCSU booklet	• Same as co-design with nurses • Design toolkit with: typefaces, pictograms, etc.
Interview w/ ward nurses	• 2 ward nurses	• Section 1: questions about patient behavior and info needs in hospital stay • Section 2: questions about nurse experience in supporting patients	• Interview script • Foorplan of hospital ward.

2.2.2. Usability test 1 – Existing booklet

Usability testing was also conducted with the booklet currently used at JGCSU. This first usability test allowed the researchers to gather further evidence on the problems with the existing booklet. It also provided another layer of data on the interaction of the user with the booklet, as well as their feedback after such interaction. Five participants were recruited from the general public, as it was important to have participants new to the information in the booklet to avoid clouding the results, i.e. former surgery patients would be more familiar with the information and therefore more likely to find the information faster and more accurately.

Participants were requested to find answers to 14 recovery-related questions in the booklet, and under specific scenarios that bowel surgery patients would face. Participants failed to answer 30% of the questions and spent an average time of 22 minutes to find the information (the quickest time was 11 minutes and the slowest 33 minutes). In terms of opinion, the results of the usability testing were in agreement with the results from the questionnaire: A5 booklet (100%); checklist to emphasize key points (80%); visualization should be included as it makes information easier to find (selected 2 times), more engaging (selected 2 times) and easier to understand (selected 1 time); there was a preference for pictograms (selected 5 times), with colored and flat style being the most popular (selected 3 times), followed by colored and outlined style (selected 2 times); including imagery in the booklet was considered helpful (80%), but participants commented that the existing imagery in the booklet was not seen as being relevant to support the surrounding text and enhance comprehension; cool colors were considered to be suitable for a booklet on surgical information – blue (selected 4 times), purple (selected 4 times), and green (selected 2 times).

2.2.3. Visual survey of existing booklets

In addition to a preliminary questionnaire with patients and preliminary usability testing with members of the general public, it was also important to survey the content and design features of existing booklets to identify examples of good and bad practice. This selection was based on design principles from the literature. A total of 54 bowel surgery recovery booklets were collected and evaluated. These were all written in English and from a few countries around the world.

Results show that, in terms of content, the majority of booklets did not include some important information relating to 'after the operation' (e.g. observation, coughing and Heparin injections), and 'daily recovery' information. Information on complications (e.g. passing urine and abdominal pain) was also infrequent. The majority of the booklets included information on diet, exercise and pain control. In terms of design, most booklets were overall legible: 10-12pt font; sans serif font; a maximum of 2 colors for the text; bold for emphasis; text justified to the left; sufficient interlinear spacing; one-column. However, the vast majority of the booklets were text dense, lacked visualization or suitable visual aids.

2.3. User needs

2.3.1. Interview with surgeon

An interview was conducted with a surgeon from JGCSU to clarify the content of the existing JGCSU booklet and the aims of the ERAS (Enhanced Recovery After Surgery) programme. This was the first step for the research team to understand the intricacies of a sensitive and complex subject. A thorough description was given of the patient journey and the roles of both surgeons and nurses during that journey. In particular, it was emphasized how home recovery is a period where patients feel particularly lonely and anxious because suddenly they lose the support system they had while at hospital. Therefore, while other sections are currently quite comprehensive, the 'Home' section and the emotional support and advice that patients need was seen as one of the sections which could be further developed when redesigning the booklet.

2.3.2. Co-design (3 different groups)

Co-design is a method used in design where users, clients, and stakeholders are involved in the design process to share deep insights in solving problems and testing new designs. It has the advantage of immediately reflecting user needs and views (Steen et al., 2011; Muratovski, 2016).

For this study, however, we decided to have three distinct co-design sessions where stakeholders were grouped according to a specific role and responsibility throughout the recovery process. All groups had at least one designer per participant to assist in interpreting design tasks and design language: Group 1 – Nurses; Group 2 –Surgeons; Group 3 – Patients. This is what we will define, for the purposes of this paper and research, as a 'within co-design' approach, which in turn contrasts with what we define as 'in-between co-design' approach. 'Within co-design' is here interpreted as the collaboration and sharing of ideas among a group of users with a common goal, with similar roles in the process, with the same needs and dealing with the same problems. While 'in-between co-design' is here interpreted as the collaboration and sharing of ideas among a group of users with a common goal, and in the same process but with different roles, with different needs and dealing with different angles of a problem.

The reason why we felt the need to identify and define two different strands of co-design and use the 'within co-design' approach for this study, was due to the following. There is a default hierarchy in the healthcare chain. A 'within co-design' approach would allow each group to freely express their needs, their creativity, and their problem-solving insights without feeling the pressure to compromise or feeling uncomfortable to express ideas and solutions. Instead, our decision was that the researchers would have the responsibility to find the middle ground between the solutions delivered by all groups at the stage of analyzing the data. Moreover, certain co-design session activities did not require all stakeholders, as described below.

Co-design session with nurses – Group 1

In the 'within co-design' session with 3 nurses, participants were asked to reorganize the information structure for the booklet and to identify information content appropriate for different mediums. To this end, card-sorting was used with 110 topic cards mirroring the ERAS principles and the information in the existing JGCSU booklet. In addition, the appropriate types and content of visualized information were identified by asking nurses to compare competitor and original booklets. Information that should be included in different mediums was classified through labelling using stickers with four different colors.

Co-design session with surgeons – Group 2

The co-design session with 3 surgeons followed the exact same procedure.

Co-design session with former patients – Group 3

The co-design session with former patients followed the same procedure used with the medical staff. But, in addition, participants were also asked to design their own booklet by using various design elements for one section of the existing JGCSU booklet. This enabled researchers to gain objective data on the layout, typography and visualization that participants preferred and were more comfortable with, but also gave a deep understanding of their views and reasons (Martin and Hanington, 2012; Muratovski, 2016). Four participants were recruited through the Surgical MedTech Co-operative of Leeds Teaching Hospital (three female and one male) who had previously undergone bowel surgery.

Findings

Following a 'within co-design' approach has resulted in very insightful and interesting results that might not have been found otherwise. There is a visible disparity in the results for each group of users, which overall reflect the major role each group has during the surgery and recovery process, and show that (Figure 1 - top):

G1– NURSES] The nurses focused mostly on when the information is first given to the patients, which meant that their information structure was heavy in the pre-operative stages. They also added an immediate post-op section;

G2 – SURGEONS] The surgeons focused on both pre-operative and post-operative stages (mainly hospital recovery). The surgeons noted that the recovery stage had repetitive information that should be removed. Moreover, they clearly explained that defining daily recovery goals is unrealistic and not applicable to all patients, i.e. each patient recovers at different speeds and imposing rigid goals will only generate stress and anxiety and have an impact on their wellbeing. Therefore, this section should be re-written completely.

G3 PATIENTS] The patients focused on having the information organized in a sequential and balanced manner that mirrored recovery, as well as the need to include more information on recovery at home. As explained by patients, they go from a situation of regular support and attention from the medical

staff while at hospital, to suddenly having to be auto-sufficient in their recovery while uncertain of what to do exactly and whether certain symptoms are normal, which generates feelings of loneliness and anxiety.

All views and information structures were taken into account and combined to form a final information structure, shown in Figure 1 (bottom). In this structure the 'Before Surgery' chapter was developed to include health optimization and surgery preparations; the 'Hospital Recovery' chapter was summarized to eliminate the daily goals; more information was added to the 'Going Home' chapter. All other results are presented in Table 2.

FIGURE 1

Information structure that emerged from the 'within co-design' approach.
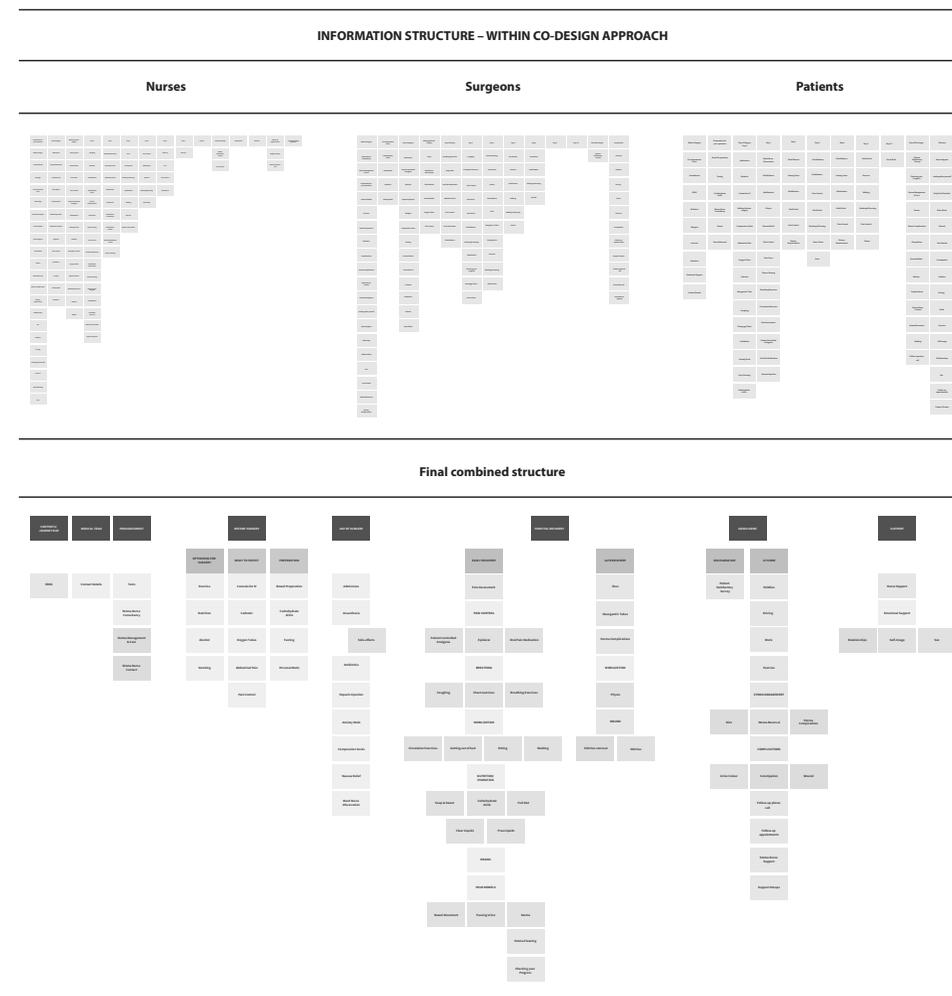
INFORMATION STRUCTURE – WITHIN CO-DESIGN APPROACH

Nurses | Surgeons | Patients

Final combined structure

T A B L E   2

Feedback from the co-design sessions. Distinction between medical
staff and former patients as the sessions varied in one task.

CO-DESIGN SESSIONS FEEDBACK		
	NURSES AND SURGEONS	**PATIENTS**
Improvements and suggestions	• Emphasize the benefits of the ERAS programme and mobilization as they reduce recovery time and increase success of recovery. • The contents page is very important and should be a visualized overview of the content with pages. • Present the recovery process as a cycle to show that all stages are interrelated. • Consider the use of checklists that are likely to cover patients' different recovery speeds. • Do not limit recovery to a daily timeline as this is unrealistic. • Emphasize the concept of team work and communication between patients and the medical team. • Present the medical team in a visualized form to reflect their different uniform colors that patients can easily identify when in hospital.	• Include information about emotional support and charities. • Include links to a website to avoid information overload. • Present pain assessment information using a combination of numerical scores and visual images of facial expressions. • Include visualization of medical equipment to help patients identify them and reduce anxiety.
Types of visualization	• **Pictograms**: summary of pre-assessment clinic / pain score / acceptable exercise / day 1-7 goals. • **Illustrations**: patient journey map / fasting / circulation exercises / breathing exercises / coughing / getting up from bed / nutrition and diet / urine colour. • **Diagrams**: contents page / patient journey map / fasting / carbohydrate drink / mobilization goals / nutrition steps during hospital recovery. • **Checklists**: personal medications / ward observations / daily goals / complications symptoms / going home goals / dietary tips.	• **Pictograms**: eating and drinking; day 1-7 goals / getting ready to go home / complications. • **Illustrations**: breathing exercises / coughing; pain control / daily goals / getting ready to go home / complications. • **Diagrams**: fasting / nutrition steps during hospital recovery / pain control. • **Checklists**: personal medications / before surgery / the evening after surgery / contact details.
Feedback when co-designing the booklet	N/A	**Typography** • Better to use the same typeface with different weights; • Prefer bold over underlining to emphasize information; • Good to apply eye-catching headings. **Visual language** • Refrain from describing older people; • Have a balance of gender and ethnicity; • Favor flat vector, realistic and clear illustration; • Use images if correlated to the text. **Layout** • Use diagrams and flow charts; • Divide informatiin into chunks; • Use bullet points instead of long paragraphs.
Content distribution per output	**Website** (with link in the booklet): • Optimizing your health; • Bowel preparation; • Pain control methods; • Stoma management and reversals • Car insurance; • Emotional support and charities. **Environmental infographics** • Patient recovery journey maps; • Visualized distance measurement; • Card design to provide patients personalized daily goals.	• N/A

2 . 3 . 3 .   I n t e r v i e w   w i t h   w a r d   n u r s e s

Interviews with two ward nurses were conducted to gain further insight on how to improve communication between the medical team and the patients. This time focusing more on environmental information that provides additional information to patients while moving around the ward, which is required in their first days of recovery while at hospital. To this end, the study conducted semi-structured interviews divided into two main parts: Part 1] questions about patient ward activities, the degree of patient involvement in the recovery process,

and the information they need; Part 2] questions about how the medical team communicated with patients and how to encourage active participation of patients. Two senior ward nurses at John Goligher Colorectal Surgery Unit in Leeds Teaching Hospital were interviewed.

Results show that, in terms of patient activity and the information they need: a) patients usually spend time in the hospital and there is no family reception room or TV lounge; b) questions frequently asked by patients are the length of hospitalization, mobilization, nutrition, and the location of toilets; c) from the point of view of the ward nurses, the information related to mobilization is most important for patients during their hospital stay. In terms of problems and improvements, results showed that: a) few patients read the ERAS information that is displayed on noticeboards on the corridor, and therefore there is a need to design information that can draw patient attention and that is easy to understand; b) patients tend to only move around their room, and therefore a solution could be to design information on mobilization that patients can easily recognize and follow, as well as personalized information specifically on daily goals that is easy to find, i.e. without much physical effort.

2 . 4 .   S u m m a r y

A comprehensive first stage of primary research, encompassing eight research sub-studies, gave us excellent insight of the design problems with existing patient information on the recovery of bowel cancer surgery, as well as of the needs patients have, and of those who have to communicate with them such as nurses and surgeons.

All research methods were equally valuable for the mixed-methods approach we followed in order to gather reliable findings. However, the co-design sessions following a 'within co-design' approach were certainly very valuable at giving us an extra layer of unbiased and uncompromised insight, which would not be possible to acquire with a more traditional 'in-between co-design' approach. The way information was organized and structured by the nurses and surgeons reflected the main role they have during the surgery and recovery process, i.e. nurses playing a major role at preparing patients for the surgery and surgeons playing a bigger role during patient recovery after surgery. Patients, on the other hand, the primary end-users, felt they needed help across all stages of the preparation and recovery process and certainly need information for recovery at home (when they feel very isolated, unsure and anxious).

3. Design development and iteration [Booklet]

With all the data and insights gathered in stage one of our study, our next challenge was to design a new booklet and respective companion outputs. Section 3 describes and discusses the design development of the booklet and all the testing and iteration conducted. Section 4 describes the empirical testing conducted to validate the booklet design by measuring performance (time and accuracy of finding information) and collecting opinion of participants. Only after gathering all this evidence on the reliability and validity of the new structure of the booklet and information visualisation applied, did we proceed with creating, testing and iterating a website that is an extension of the booklet and environmental infographics that are also a companion output to the booklet (described and discussed in Section 5).

3.1. Design considerations from primary research and literature

In order to meet the needs of the users, the design development of the booklet took into consideration both their comments and suggestions, as well as research-based design and cognitive principles collected through the review of literature. Cognitive and perceptual 'tricks' put forward by some researchers (e.g. Bettman et al., 1986; Patterson et al., 2014; Coley, 2017; Lonsdale and Lonsdale, 2019) are also included. All principles are shown in Table 3. It was quite refreshing and interesting to find out that, despite not having design expertise, the choices made by participants were largely in line with design guidelines from the literature.

3.2. Design development

With the aim of redesigning the existing JGCSU booklet to increase understanding, accessibility of information and user attention, an iterative design process involving users or representative users was followed. The feedback for the booklet was collected through interviews with stakeholders, a comparative usability test with a representative group of the general public, and interviews with previous bowel surgery patients.

3.2.1. Iteration 1 – Interview with stakeholders

Before designing, the content of the existing booklet was rewritten in order to conform to the new information structure ideated in the problem identification stage. The information was pieced together by the researchers using various enhanced recovery booklets from various NHS hospitals in the UK. The final content was then approved by the Leeds Teaching Hospital Colorectal Unit specialist nurses and surgeons.

The booklet was redesigned to visually follow the NHS brand colors and use a library of new self-explanatory pictograms in full color. Different design versions of the booklet were developed and included 2 pictogram styles, 15 layout variations and 4 cover variations. An interview was then conducted with two representatives of the Leeds Teaching Hospital Colorectal Unit medical team.

Improvements suggested included: change the alignment of some pictograms in the Daily Recovery infographic; use softer shades of green and oranges; add sanitary masks to surgeons and remove their white coats; merge the medical team with the patient journey map; use iconographic cover without realistic illustrations; if showing an illustration of the bowel, do not have it cut (as this is what is going to happen in their surgery).

TABLE 3

Design and cognitive principles considered in the design solutions to the problem identified in this study.

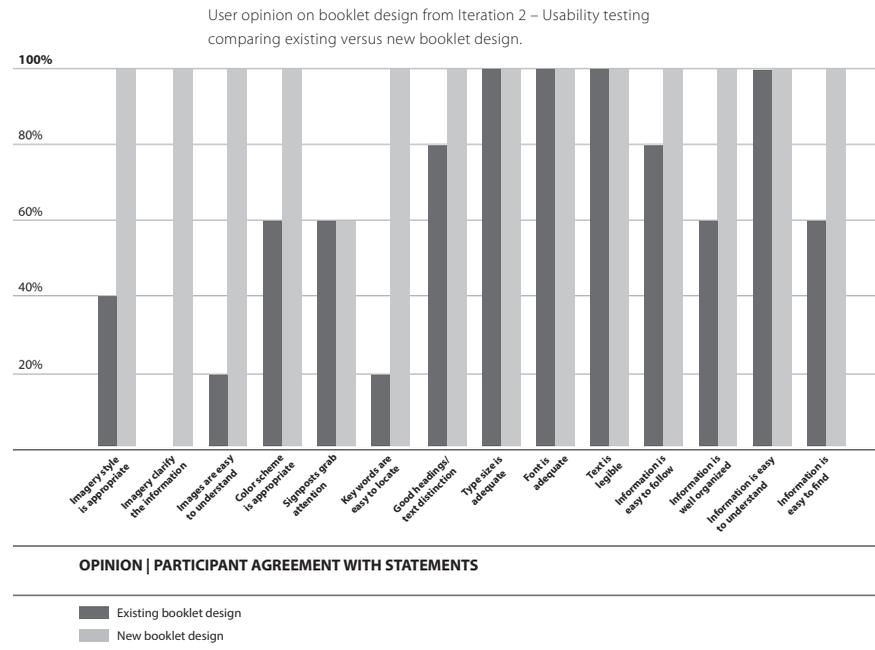|	FINDINGS FROM THE LITERATURE	FEEDBACK FROM USERS
Typography	• Maximize text legibility using: adequate type size (9- and 12-point size); high contrast between text and background; and legible typeface families. • Avoid use of all-caps. • Use bold over italic to emphasize text. • Make the contrast between the title, headings and main text clear in terms of size differences and the features of the typeface. • Do not use more than two type families, but different weights consistently.	• Sans Serif typefaces were perceived as more legible. • Bold weights were preferred to signal keywords. • Type size of 10 to 12pt was chosen for the main text and 13pt and above for headings. • Headings need to be distinct from the main text by using all-capitals and/or bold weight.
Color	• Use color sparingly to: emphasize words; make headings stand out; signal relationships within a document; show hierarchal levels; provide structure and organization in a document. • Use color coding in a consistent and logical manner, so that information is quickly and easily understood. • Avoid bright, highly saturated (primary) colors because they are visually too obtrusive and can impair legibility. • Use colors with enough contrast and avoid complementary colors. • Identify the colors that should be favored and the colors that should be avoided with a specific topic.	• Colors prefered for the subject of Colorectal Surgery were: blues, purple, and warm greens. • Reds and oranges should only be used to grab attention and for important information, but oranges should be favored. • Color could be applied to clearly distinguish different sections. • Information could be placed in a colored box to make it stand out.
Visualization	• Use imagery that relates to the text to present information at a glance. • Use visual aids (e.g. pictograms, diagrams) alongside the text to distill information and enhance retention and recall. • Use graphic visual cues such as signposts, arrows, bullet points and text weight to create entry points, flow and punctuation. But, they should be used sparingly and with purpose. • Use a background shape to make icons clear (e.g. within a circle). • Use captions to direct attention within images. • Create enough contrast between visualization and background. • Avoid visualization to inform that is illustrative or abstract.	• Visualization is highly needed due to the age of the target audience, varied literacy levels and mental state during surgery recovery. • Visualization should reflect and support the main text. • Visualization should be either vector illustration in flat color or outlined pictograms with realistic color fills. • Visualization depicting humans should be age, gender and ethnicity balanced and follow realistic proportions.
Layout	• Left align large amounts of text to avoid rivers and excessive hyphenation. • Use line lengths of around 60 to 70 characters per line and additional interlinear space of one to four points, for print material. • Denote text paragraphs with an indentation of one to three ems for large amounts of text, or separate them with one line space. • Use different size headings and color coding to aid navigation and hierarchy. • Use generous margins to avoid cluttered pages and for functional reasons such as making notes. • Apply lines and arrows to guide users through the information.	• Information should be written in concise and direct sentences and presented in bullet points (where possible and appropriate). • A5 is the ideal booklet size as it is portable. • Page layout should follow 1 or 2 column grid. • Generous white space should be used to allow users to write down personal notes.
Cognitive tricks	• Choice – limit the number of choices given to help the user make a decision as to what information to read and/or prioritize. • Chunking – group items of information together in a meaningful way through common features (color and shape) and Gestalt principles. • Complexity – do not include irrelevant and extraneous graphic elements that only distract and make the user spend time and effort processing them. • Consistency – use a common organization by placing repeated information consistently between sections or outputs to easily locate desired information. • Emphasis – emphasize information by using different colors or sizes of type. • Familiarity – use symbols (and colors) that can be quickly understood by the users, i.e. that builds on the user's knowledge. • Focus – increase focus by using appropriate visual cues such as arrows pointing to relevant information. • Hierarchy – present information hierarchically and in the order users are likely to read it, or you want them to read it. • Order – place important information first as this will affect how subsequent information is perceived and whether to continue to read or not. • Quantity – reduce the number of graphical elements, as this increases the power and value of each visualization. • Reasoning – design information to help help users draw inferences and conclusions in order to understand and act on the information. For example, color-concept associations help discriminate between categories (red for 'don't' and green for 'do'). • Reminders – provide visual cues to help remember information when moving between sections, outputs, etc. • Simplicity – present information in its simplest form to be understood by both current and users new to the information. • Visual cueing – use salient cues to call attention to a visualization and make it noteworthy.	• The layout should be simple and with clear chunking of information. • Organization of information should be in distinct chapters, which may be color coded. • Enclosed information in colored boxes tends to be overlooked and would require an extra level of emphasis (e.g. icon) to be noticed. • Contents page should have numbers and preferably give a visualized overview of the booklet's content. • Facial expressions combined with numerical scores should be used to visualize pain assessment scores.
Literature reviewed	Bettman et al., 1986; Pettersson, 2002; Paul et al., 2004; Houts et al., 2006; Katz and Weiss, 2006; Lipton, 2007; Whittingham et al., 2008; Wilson and Wolf, 2009; Baer and Vacarra, 2010; Dickinson et al., 2010; Pettersson, 2010; Choi, 2011; Tae et al., 2012; Castel et al., 2013; Bateman, 2014; Lonsdale, 2014; Patterson et al., 2014; Strizver, 2014; Pettersson, 2015; Williams, 2015; Del Re et al., 2016; Tetlan and Marschalek, 2016; Coley, 2017; Dickinson and Gallina, 2017; Skopal, 2017; Martin, 2018; Lonsdale and Lonsdale, 2019; Lonsdale et al., 2020.	

3.2.2. Iteration 2 – Usability testing comparing existing versus new booklet design

The full booklet was then redesigned, and in order to test and evaluate the effectiveness of the new design, a comparative usability test was conducted between existing and new booklet design. It was important that participants had no knowledge about bowel surgery recovery information (either as a patient or as a caregiver), to avoid clouding the results. Therefore, ten participants from the general public aged 50+ were recruited as representative users and divided into two groups of 5 participants for each booklet design version. The test was divided into 2 sections and included a performance task of 15 questions where both time and accuracy of finding information were measured. This was followed by an opinion-based questionnaire where participants were asked whether they agreed or disagreed (5-point Likert scale) with ten statements regarding the booklets' information structure, visualization, color and layout.

The results showed that in order to find information accurately and reach a similar accuracy level (i.e. 80-82%), participants spent more time with the existing booklet design (238 seconds) than with the new design (191 seconds). In terms of preference, participants were in favor of the new design, and clearly indicated the value and importance of visualization, of a well-structured layout and of a good hierarchy/emphasis (Figure 2). The new design also gave a sense of reassurance and comfort to participants. Improvements suggested included: chapter color coding needs to be more evident; surgery preparation needs a timeline; signposts need to be more attention grabbing; 'before surgery' chapter needs better information organization and flow; topics such as driving, working and sexual activity should be included under a different heading.

FIGURE 2

User opinion on booklet design from Iteration 2 – Usability testing comparing existing versus new booklet design.

OPINION | PARTICIPANT AGREEMENT WITH STATEMENTS

Existing booklet design
New booklet design

3.2.3. Iteration 3 – Interview with medical team

The booklet was further revised and evaluated again through a one-to-one interview with 2 nurses and 1 surgeon. Only a few more improvements were suggested: rewording certain text; and redesigning particular pictograms in order to reduce appearance of needles.

3.2.4. Iteration 4 – Interview with former patients comparing existing versus new booklet design

The booklet was evaluated one final time through one-to-one interviews with 5 former bowel surgery patients. In these interviews, participants were asked to directly compare the existing and the new design and chose which of the two made the information: easier to find, easier to understand, easier to memorize, more engaging, and more professional. Additionally, they were asked to choose 6 words for each booklet out of 32 descriptive words (8 positive and 8 negative descriptive words, 8 positive and 8 negative emotive words) to express their opinions and feelings about the designs.

The results show a clear preference for the new design over the existing design. All participants thought that the new design made the information: easier to find (100%); easier to understand (100%); easier to memorize (100%); more engaging (100%); and more professional (100%). Furthermore, words chosen for the new design were positive: a) participants thought the design was easy to use (selected 4 times), clear (selected 3 times), straightforward (selected 3 times), attractive (selected 2 times), and engaging (selected 2 times); b) participants felt: comfortable (selected 4 times), well informed (selected 3 times), satisfied (selected 3 times), and confident (selected 2 times). On the other hand, the majority of words selected for the existing design were negative: a) participants thought the design was unattractive (selected 3 times), dull (selected 2 times) and time consuming (selected 2 times); b) participants felt disconnected (selected 3 times), confused, overwhelmed, frustrated and bored (all four selected 2 times). Improvements suggested were minor at this stage and included: chapter color coding needs to be further improved; certain text should be further simplified (written in plain English).

4. Evaluation and validation [Booklet]

4.1. Participants and test material

Once the new booklet design had gone through various stages of iteration, an experimental test was conducted to ascertain the validity of the design.

A total of 60 participants were recruited to complete the experimental test used for this evaluation and were split into 2 equal groups. In Group 1 all participants used the existing JGCSU booklet design (Existing Design – Figure 3), and in Group 2 participants used the new and improved booklet design (New Design – Figure 4 and Figure 5).

FIGURE 3
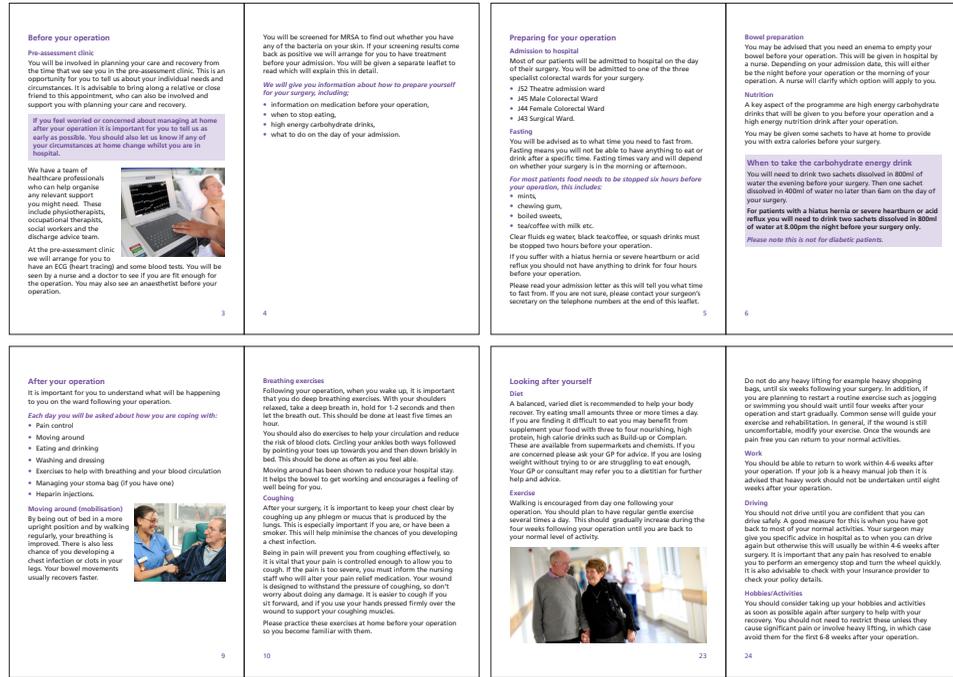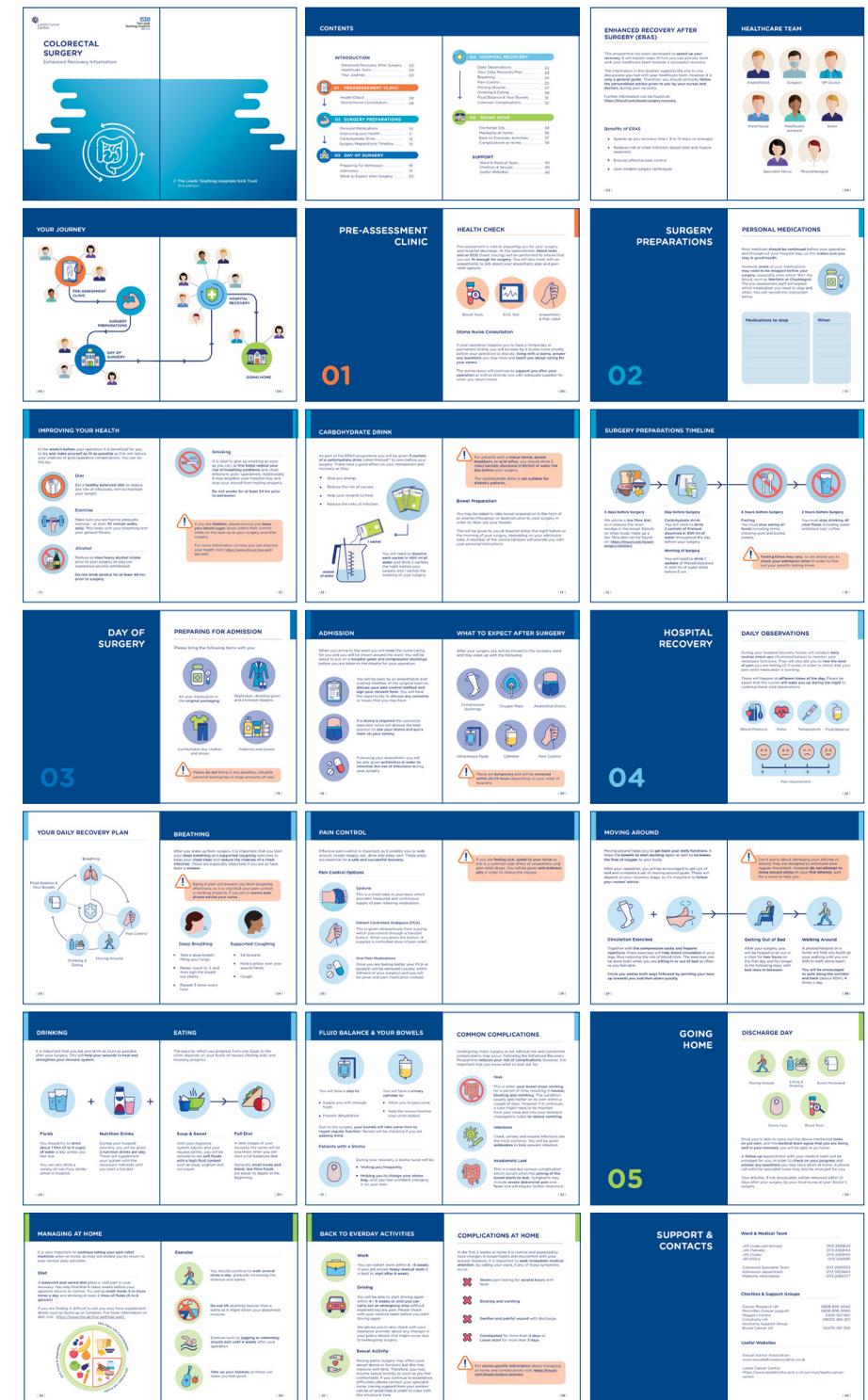
Existing JGCSU booklet design – A few pages of the booklet.

FIGURE 4

Redesigned JGCSU booklet – A few pages of the booklet.

FIGURE 5

Redesigned JGCSU booklet – All pages.

Participant demographics, including their prior knowledge of bowel surgery, were balanced between the two groups. Both groups had the same number of participants (19 female and 11 male) and educational levels (16 below university level and 14 with university degree). Groups also had a similar age range (G1 = 63.4; G2 = 66 years old); a similar nationality (G1 = 29 and G2 = 30 English native speakers); a similar prior knowledge of bowel surgery recovery (G1 = 9 never heard about information on bowel surgery recovery, 16 heard about bowel surgery, 4 read some information somewhere, 1 looked after someone with bowel cancer; G2 = 9 never heard about information on bowel surgery recovery, 17 heard about bowel surgery, 1 read some information somewhere, 3 looked after someone with bowel cancer.

4 . 2 .   P r o c e d u r e

All 60 participants were tested individually and completed the experimental study, which was divided into 2 sections. In section 1, participants were asked 15 content related questions which they had to orally answer by locating the respective information from their assigned booklet. Performance was measured by the time to find the information and the accuracy of the answers given. In Section 2, a recorded interview was conducted where participants were provided with the alternative booklet design (new design if testing the original design and vice versa) and were asked their opinion. Five statements were read out and participants were asked to agree or disagree based on a 5-point Likert scale and then explain their choice. The statements were used to find out whether participants felt that with the alternative design it was easier to find, understand and memorize the information, as well as whether the alternative design made the information more engaging and more professional than the booklet they used in the performance test.

4 . 3 .   R e s u l t s

4 . 3 . 1 .   T i m e   a n d   a c c u r a c y

An Independent Two Samples t-test was used to compare the results of the given performance task between Group 1 (Existing Design) and Group 2 (New Design). Results show significant differences between the performance of the 2 groups (Figure 6). Participants in Group 2 (New Design) took significantly less time to find information (M=790.70, SD=170.023) than Group 1 (Existing Design) (M=964.40, SD=250.858); t(58) =3.139, p<0.01. A significant difference was also found in accuracy where the information found by Group 2 was significantly more accurate (M=13.40, SD=1.329) than with Group 1 (M=11.23, SD=2.254); t(58)=−4.535, p<0.001. This provides evidence of the superiority of the New Design over the Existing Design in terms of user performance, i.e. speed of finding information and accuracy of the information found.

F I G U R E   6

Mean time (time in seconds taken to find the information) and mean accuracy (number of correct answers) between 'Existing' and 'New Design'.
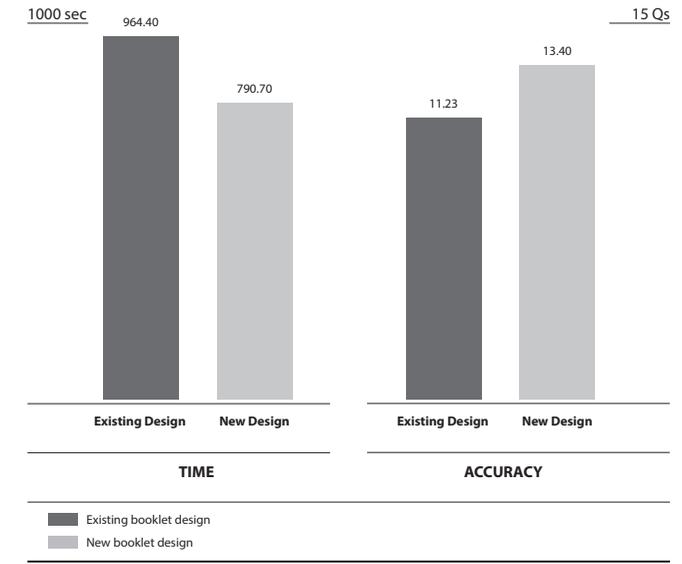
4 . 3 . 2 .   O p i n i o n

Participants' opinion of the Existing Design was also very negative when compared with the New Design. As shown in Figure 7, in Group 1 very few participants (10%) agreed that the Existing Design made the information: easier to find; easier to understand; easier to memorize; more engaging and more professional than the New Design. However, in Group 2 the majority of the participants (83% to 100%) agreed that the New Design fit the statements given. Specific comments mentioned that compared to the dull and daunting text heavy Existing Design, the New Design was easier to navigate and understand because of its: contents page that facilitated the location of specific information in the booklet and provided a clear sequence to the information; engaging visuals and diagrams that explain the text at a glance; layout that organized the information in manageable chunks with distinct and clear headings.

Comparison between percentage of participants in Group 1 and 2, who agreed with the statements.

OPINION | PARTICIPANT AGREEMENT WITH STATEMENTS

- Existing booklet design
- New booklet design
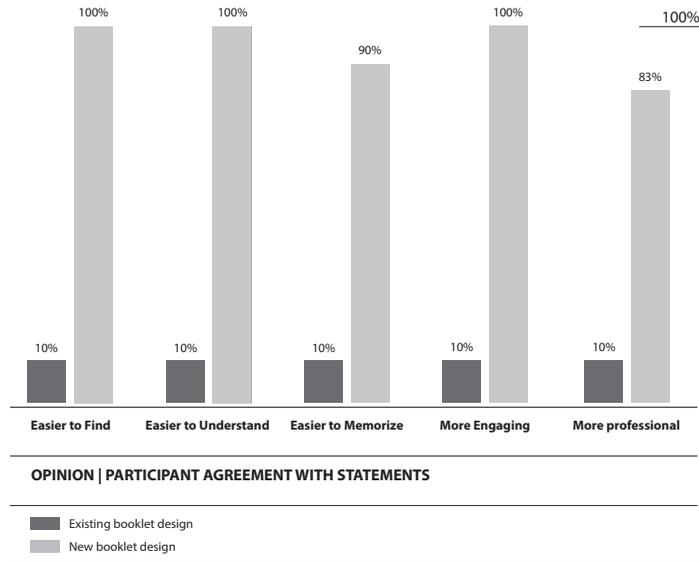
When participants were asked to choose three words to describe both their opinion and feelings after using the assigned booklets, the results were as follows. In Group 1 (Table 4) the majority of participants chose negative words to describe the Existing Design and their feelings after using that design. They felt that the Existing Design was time consuming (selected 18 times) and felt confused (selected 13 time). However, on a positive note, some participants also deemed the Existing Design to be helpful (selected 14 times) and felt that they were still well-informed (selected 10 times). In Group 2 (Table 4) the majority of participants chose positive words to describe the New Design and their feelings. Participants found the New Design easy to use (selected 23 times) and clear (selected 18 times). In terms of the way they felt, participants felt well informed (selected 24 times), confident and comfortable (both selected 15 times). This clearly indicates that participants' perceptions match their performance results and provide further evidence that the New Design is better than the Existing Design despite the latter receiving both negative and positive feedback.

Further comments highlighted the fact that the Existing Design was too text heavy and even though still relevant and informative, required the user to read entire paragraphs to find important information. Additionally, the written content was vague and non-sequential, which confused participants as to what they had to do in specific situations, such as after waking up from surgery. The New Design, on the other hand, received more positive feedback, with participants describing the use of visualization and color both as engaging and helpful. This was particularly the case with the contents page as it clearly indicated the stages a patient would go through and the relevant information needed in each stage. Moreover, the well-organized layout and the emphasis of important information through bold text and warning signposts, made participants feel reassured and confident that they found and understood the information they needed.

Participant choice of 3 words (number of times selected) to describe their opinion and feelings about the design of the 'Existing' (Group 1 – Left) and 'New' (Group 2 – Right) booklet design.

G1 | EXISTING BOOKLET

Opinion on design (N = 30)		Feelings about design (N = 30)	
Time consuming	18	Confused	13
Helpful	14	Well-informed	10
Hard to use	12	Frustrated	10
Dull	11	Stressed	10
Overwhelming	10	Disconnected	9
Unattractive	5	Overwhelmed	9
Frustrating	5	Bored	8
Confusing	4	Satisfied	5
Staightforward	3	Confident	3
Ineffective	2	Annoyed	3
Easy to use	2	Comfortable	2
Clear	2	Reassured	1
Effective	1	Impressed	1
Attractive	1	Empowered	1

G2 | NEW BOOKLET DESIGN

Opinion on design (N = 30)		Feelings about design (N = 30)	
Easy to use	23	Well-informed	24
Clear	18	Confident	15
Helpful	12	Comfortable	14
Straightforward	12	Satisfied	11
Effective	9	Reassured	11
Attractive	6	Impressed	9
Engaging	4	Empowered	2
Empowering	1	Disconnected	1
Unattractive	1		

- Positive words
- Negative words

4 . 4 .   S u m m a r y

Overall, results were more positive for the New Design than for the Existing Design. A significant improvement was found in participants' performance (measured by the time and accuracy of finding information and answering the questions correctly) when using the New Design. In addition, participants also gave more positive feedback towards the New Design and felt confident and reassured rather than confused and frustrated. All in all, these results provide evidence that designing patient information combining text and visualization, following research-based information design principles, cognitive principles, and using a variety of user-centred methods, increases understanding of the information, enhances user engagement and minimizes user frustration and uncertainty.

5. Additional design outputs [website and environmental infographics]

5.1. Design rationale and guidelines

After validating the design of the booklet, a website and environmental infographics were also created as companion outputs to the booklet. Stakeholder needs were primarily identified during the co-design sessions conducted with former bowel surgery patients and medical professionals; during one-to-one interviews with ward nurses; and through the questionnaire completed by former patients.

Along with visualization and a restructuring of the booklet's information, the creation of a **website** was also suggested, with the questionnaire results showing the website as the most preferred companion output by 90% of participants. A website was seen as an output that could provide a more holistic information package with more detailed information. In fact, ward nurses pointed out that patients are generally very uncertain about what they should do during their hospital and home recovery, therefore requiring an extra level of support and reassurance during these stages.

Questionnaire results further showed a motion graphics video as the second most selected companion output (30%) and the **environmental infographics** as the third most selected (20%). The difference between these two outputs was small, which lead us to take other things into consideration. For example, our decision to develop the environmental infographics was also based on the prior-knowledge principle that activating prior knowledge improves the learning of new information (Mayer, 2001). We also took into account the research by Tetlan and Marschalek (2016) suggesting that visuals can stimulate memory and evoke prior-knowledge. Environmental infographics as a companion output to the booklet could therefore facilitate recall of prior knowledge acquired through the booklet to remind patients while at hospital of their role in the recovery process. Moreover, having a digital companion output (website) and an environmental output (infographics) was seen as being more inclusive of all ages and people with different digital and literacy skills, than having two outputs that required digital interaction and medium.

The same content and type of visualizations created for the booklet were used and adapted to these two extra outputs by following design and cognitive principles listed in Table 3, as well as design principles specific to each output (specific principles are summarized in Table 5). Principles for environmental infographics were scarce, which meant looking at infographics design literature to fill in this gap.

TABLE 5

Additional design principles considered in the design of the website and environmental infographics.

	WEBSITE	ENVIRONMENTAL INFOGRAPHICS
Typography	• Left align text and use 75 -100 characters line lengths. • Avoid use of all-caps. • Use simple and clean typefaces for screen display. • Use no more than 2 different fonts. • Use clear large headings. • Use 12 to 14 pt type size and make it easy for users to enlarge text.	• Text should be easy to read and kept to a minimum. • Use no more than 2 typeface families and make the most of different weights and colors, while maintaining consistency. • Use typefaces that effectively communicate the message of the infographic and suit the purpose of the text and of the infographic. • Prioritize key messages by increasing the size of the text and of the relevant elements. • Use orientating text to help the users understand the relevance of the infographic.
Color	• Use bold and bright colors to cue the user to new information. • Use color coding in a consistent manner.	• Use colors to focus user attention and meet the specific needs and goals of the infographic. • Use comfortable and harmonious colors to provide the right environment for effective communication to users. • Use a maximum of 3 to 5 colors to effectively highlight information. • Use color to chunk information, highlight important words, and establish a relationship between elements to help users navigate and undertsand information. • Use adequate colors to convey messages that are easy to remember.
Visualization	• Use visuals that are relevant to the information and not just for decoration. • Use images that support and improve learning. • Use icons that are simple and meaningful.	• Use simple and colorful shapes to highlight information and engage users. • Use unique graphic elements to attract attention to important information. • Use lines, rules, bullet points, and other graphic elements with the function of direction and punctuation. • Use icons with backgroud shapes to clearly communicate the meaning. • Use visual elements that can convey visualized stories without requiring additional text descriptions. • Use simple and easy-to-understand visual elements closely related to the key message of the infographic
Layout	• Avoid irrelevant information on the screen. • Place important information in the center of the screen and "above the fold". • Use longer scrolling pages when reading for comprehension. • Avoid the use or horizontal scrolling. • Make sure that page elements do not give the impression that users have reached the end of the page. • Display a limited number of information items at the same time. • Break information into manageable chunks. • Use moderate amounts of white space consistently - aim for a good balance. • Use visual consistency to allow users to anticipate where information will be located.	• Use titles that are distinct from the subheadings and the main text, that are large and with high contrast. • Use titles that quickly present the purpose of the content and the focus of the message. • Use generous white space to help users have 'visual' breaks and focus on relevant information. • Place text and associated images close together to enable integrated recognition of information. • Place visual elements in a linear structure for messages describing sequential progression. • Design layouts from left to right and top to bottom, to reflect natural eye movements when looking at information. • Keep the infographic on a single page while maintaining consistency between elements.
Navigation	• Allow access to the homepage from anywhere on the website. • Do not use thin, horizontal, pull down, roll-over activated submenus. • Avoid too many menu levels and group information into meaningful categories. • Extra and bold navigation cues (buttons) should be provided in order to facilitate navigation to previous and next pages. • Provide large targets with ample white space that require a single click. • Use text for links. • Use consistent clickable cues that are clear to the user. • Change the appearance of links when clicked. • Create " anchor links" if pages are too long and have different sections.	
Literature reviewed	Leavitt& Shneiderman, 2006; Lankow et al., 2012; Kurniawan and Zaphiris, 2013; Stones and Gents, 2015; Dunlap and Lowenthal, 2016; Travis, 2016; Murray et al., 2017; National Institue of Aging, 2017; Balkac and ergun, 2018; Lonsdale et al., 2018; Majooni et al., 2018; Martin, 2018; Lonsdale et al., 2019; Lonsdale and Lonsdale, 2019.	

5.2. Design development, testing and iteration

For the **website**, in addition to adapting the same content and type of visualizations created for the booklet, the main framework used on the John Goligher Colorectal Surgery Unit webpages was kept the same. It was important that the new design easily fit within the parent Leeds Teaching Hospital website. Therefore, the usability test conducted focused more on evaluating the ability to find information on the website using a new design, rather than the suitability of how the information was designed and visualized, as this had already been done with the booklet.

For the **environmental infographics**, since the spaces seen as adequate to include environmental infographics had already been decided during the interview with the ward nurses (pre-assessment clinic, corridor, and hospital room in the colorectal ward at the John Goligher Colorectal Surgery Unit), it was now necessary to identify the content for each space. To that end, an interview was conducted with 3 members of the medical team (2 nurses and 1 surgeon) to identify the function of each space and the information that patients need in each one of them. Content information was then allocated as follows: 1) Waiting room in the pre-assessment clinic – patient recovery journey map and the procedure followed during pre-assessment; 2) Corridor in the colorectal ward – information about the process of daily recovery in hospital and daily goals; 3) Patient rooms in colorectal ward – information on personalized daily goals. In addition, other insights from the medical team included: choose a concise layout for the recovery journey; apply sufficient negative space between images and text because existing posters on display were too cluttered with information. The possibility of providing patients with bespoke information on their recovery through cards that changed every day according to their needs, was also discussed. The medical team further suggested considering magnetic pins (instead of cards) that would stick to a patient board at the end of the bed and that could be easily used by nurses and surgeons to communicate with the patient and among themselves. Another idea was to have distance information marked on the walls to help patients identify how much they would need to move in a particular day or for a particular recovery goal. The medical team warned, however, that information on the wall or floor could be obscured by medical equipment.

Once design outputs had been carefully developed based on all research and feedback, usability testing was conducted with five former bowel surgery patients between the ages of 60 and 75 (an average age of 66 years old). Participants were recruited through the Leeds Teaching Hospital, since this time we needed former patients, i.e. participants with prior knowledge of the surgery recovery information. The test conducted was divided into 2 stages (Stage 1 – Website and Stage 2 – Environmental infographics) and in each stage both quantitative and qualitative data was collected.

For the **website**, the first section involved a task where participants had to answer 10 questions by locating information on the website and by using the 'think aloud protocol' to verbalise their thoughts and opinions. The second section involved structured opinion-based questions to identify whether the information was easy to understand and the website easy to navigate. Additionally, further opinion was collected by asking the participants to choose 3 words out of 2 lists of 16 words each (8 positive and 8 negative words for each list) in order to express their opinion and feelings about the website's design.

For the **environmental infographics**, the first section asked participants their opinion on the design of the environmental infographics for all 4 spaces, where they had to agree or disagree with given statements and then list positive and negative features for each output. All environmental infographics were presented in a simulated image showing how they would look in the real 3D space. The second section collected participant opinions on the impact of the environmental infographics on their journey while at the hospital and during their recovery process. Participants were also asked to choose 3 words to express their feelings about the environmental infographics when seeing them applied to the 4 hospital spaces.
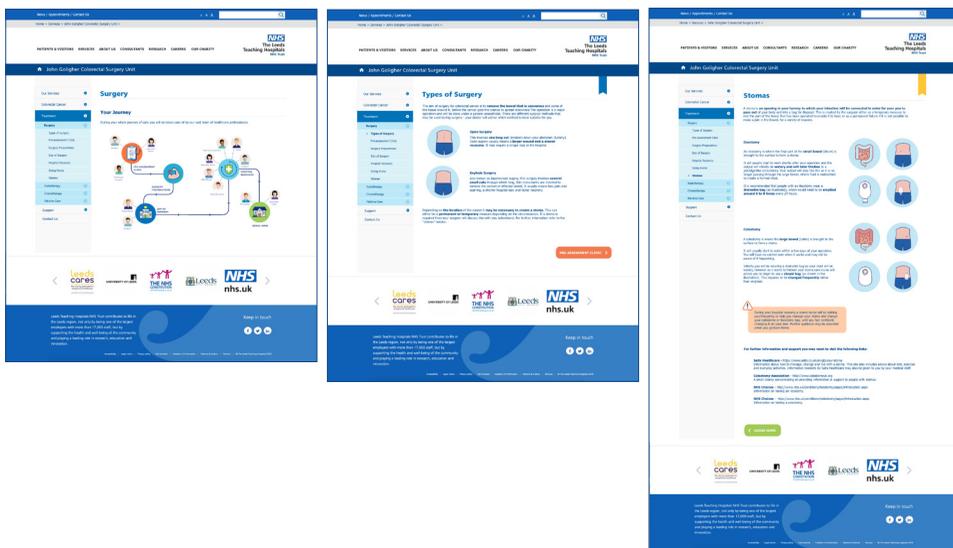
5.3. Results

The results from the **website** usability testing indicated that the information was easy to understand, with the average accuracy level of 94%, and all participants (100%) also agreed that it was easy to understand. All participants (100%) also agreed that the website was helpful. In the word choice questions, participants considered the design of the website to be attractive (selected 3 times) and helpful (selected 2 times), and felt well informed (selected 4 times) and satisfied (selected 2 times) after using the website. However, the navigation of the website was found to be tricky, with participants either choosing 'neutral' (60%) or 'disagree' (40%) for the statement that the information was easy to find. In the word choice questions, the website was in fact described as frustrating (selected 3 times) and they felt overwhelmed (selected 2 times) after using it. Through the analysis of participants' performance, in relation to their demographics, it was identified that participants over the age of 65, who were moderately computer literate, found it harder to understand the navigation menu and locate the required information than 60-62 year old participants with an advanced level of computer literacy. It is therefore clear that since older generations have less experience with website navigation, they are less likely to understand generic navigation menus. In fact, one of the main improvements needed on the website was the addition of further sub-headings in the main menu to indicate what sub-topics are discussed in each page. Finally, when asked, previous patients agreed that the website is a helpful companion to have alongside an information booklet, as it provides further information and is a great resource for relatives to educate themselves along with the patients.

The results for the **environmental infographics** usability test were very positive and in favor of using this output to help patients further in their recovery process. Participants agreed on the benefits of having environmental infographics in the hospital: it also helps caregivers to understand recovery information (100%); it motivates patients to actively participate in their recovery process (100%); it helps patients remember important information in the booklet (100%); it can help retain information better (100%); and it can help reduce stress and anxiety during their hospital recovery (100%). To express their feelings about the environmental infographics, all participants selected positive words, with the most chosen words being: well-informed (selected 5 times), empowered (selected 4 times); reassured (selected 4 times); and satisfied (selected 2 times). Participants pointed out that some of the words used seemed too formal and suggested changing them to plain English. They also suggested that for numerical distance information, it would be more motivating if patients see specific places they can to go in order to achieve their goal. They also made reference to the text and headings being slightly small.

FIGURE 8.1

Final design of the website (continues).

The final outputs of the website and environmental infographics were further revised taking into account all the usability testing results and are presented here and following (Figure 8 – Website; and Figure 9 – Environmental Infographics)

6. Overall discussion and conclusion

The aim of the present study was to to improve the understanding and accessibility of enhanced recovery information for bowel cancer surgery patients through the combined use of research-based information design principles, cognitive principles, and user-centered research methods. To this end, in the first stage of research, a wide range of research methods (quantitative and qualitative) were used to identify design problems and user needs: a survey, a questionnaire, interviews, co-design sessions with 3 different user groups, various usability tests, and experimental comparison. For the co-design sessions, an innovative 'within co-de-sign' approach was devised to be more inclusive of all user needs and expectations (patients as primary end-users, and medical staff as secondary end-users), as well as allow freedom of creativity and speech. There is a default hierarchy between patients, nurses and surgeons that could cloud the results; so much so that our findings show that each group of users structured the information of the booklet in a completely different way, one that mirrored their own needs and role in the entire surgery recovery process.

Overall, the results from all methods are unanimous in showing that the way current patient information for bowel surgery recovery is presented does not meet user needs as well as it should, because it is text heavy, dull and confusing in its structure. These characteristics were identified in the literature to cause cognitive overload and thus impair engagement and understanding. Consequently, a booklet was redesigned following research-based information design principles, cognitive principles, and several stages of design, testing and iteration

FIGURE 8.2

Final design of the website (continued).
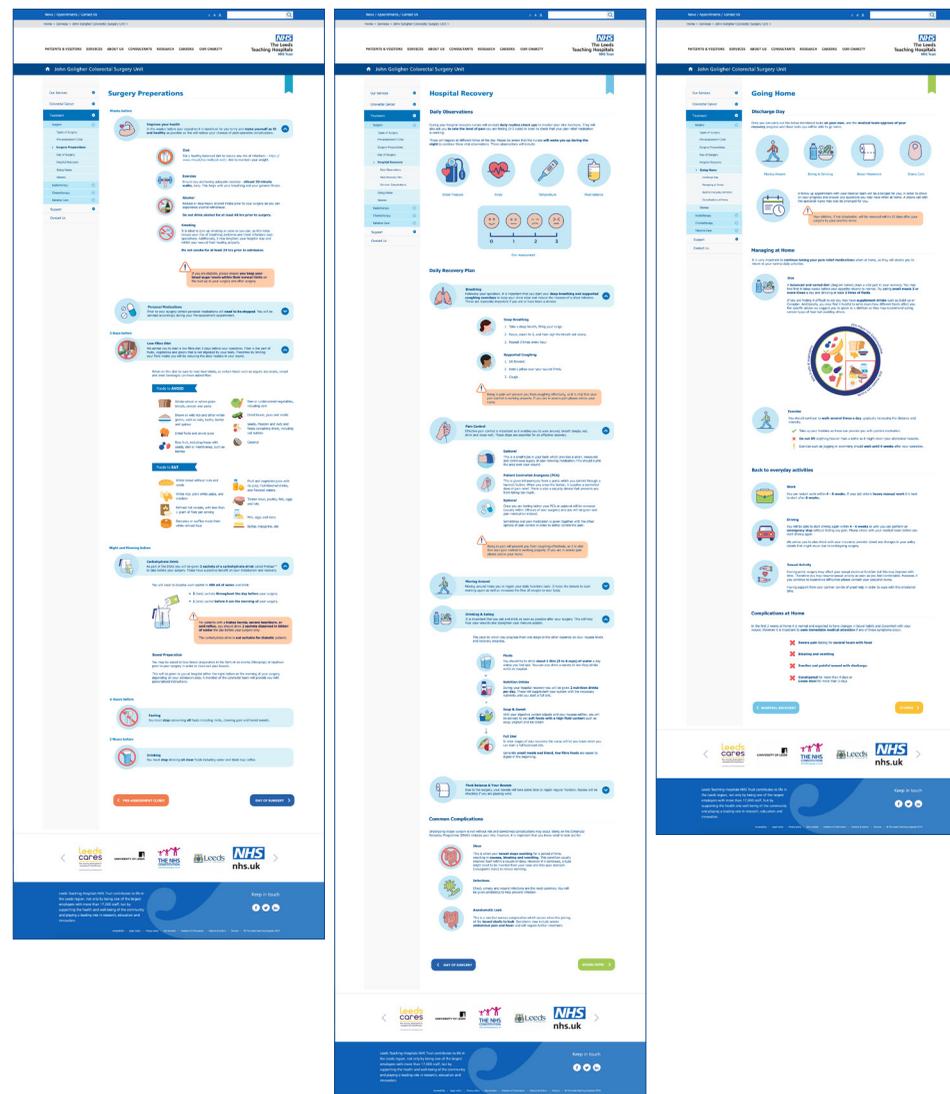
with representative users. In order to validate the effectiveness of the new design compared to the existing booklet, a final empirical study was conducted, which was clear in showing that performance when accessing, finding, and understanding information using the new booklet design (combining text and visuals) was significantly better than the existing booklet design (with text-heavy information). The effectiveness of visualized information was further supported by participants' opinions in favor of the new design and emphasizing the positive impact in terms of ease of finding information, understanding, engagement, reduced anxiety and willingness to actively participate in their own surgery recovery.

FIGURE 9

Final design of environmental infographics.
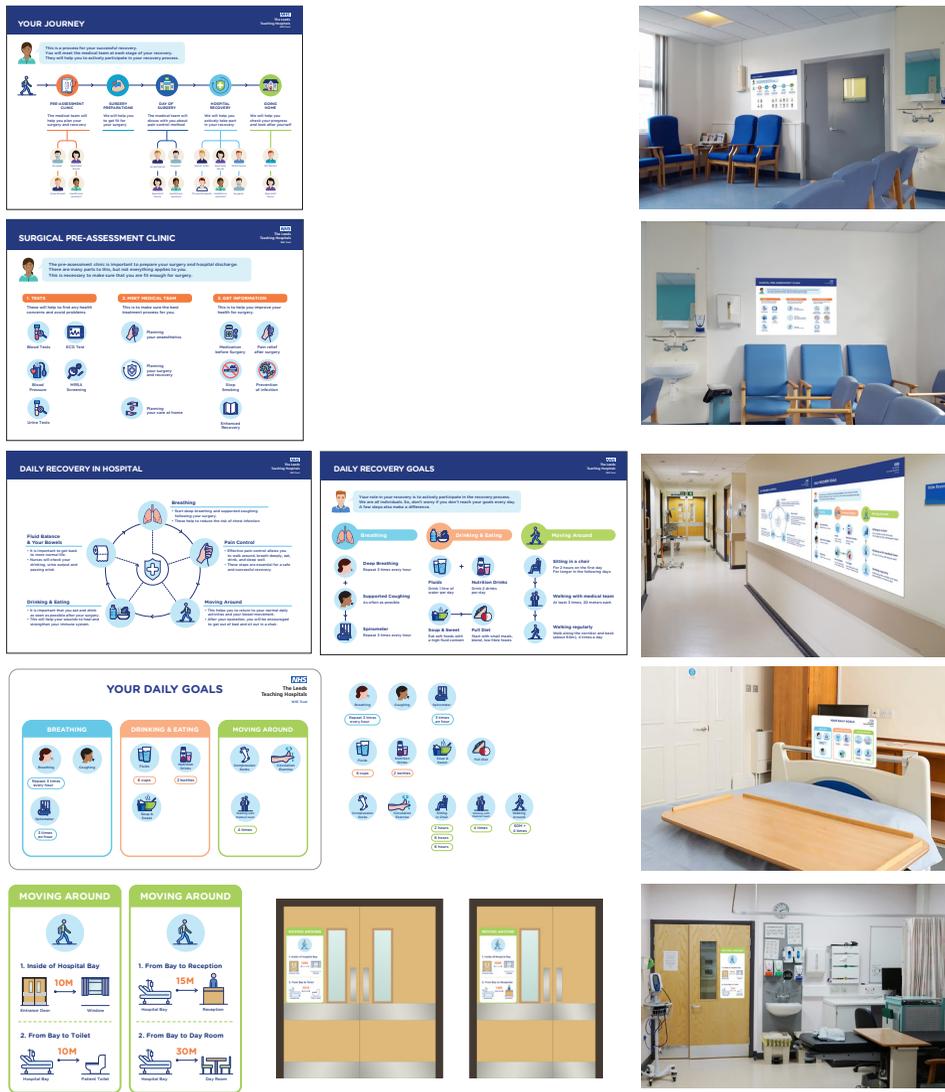
As for the website, although participants had some difficulty using it (with age and lack of digital skills being a strong factor), it was considered helpful and easy to find information on, as well as a good extension to the booklet as it provided further information for the patients and their relatives. This is especially important since it is very time consuming and difficult to find relevant information through surfing the internet (Al-Bahrani and Pulsa, 2003). Moreover, information found elsewhere in the internet might be unreliable and contradictory, and therefore cause more anxiety, distress and confusion, than actually help. As for the environmental infographics, it had high acceptance. Environmental infographics provide patients with the information they needed at a glance, attract their attention, and also give very direct instructions of what needs to be done. Participants felt empowered and saw such information

as helpful to their families and caregivers when supporting them at the hospital. Having used the same visual language and headings as the redesigned booklet also means that environmental infographics will act as memory triggers and help patients remember the information they read in the booklet.

Therefore, these results confirm the hypothesis presented in this study that bowel surgery recovery information designed according to research-based information design principles and cognitive principles, and applying user-centered research methods that involve the user in all stages of the design and research process, facilitates access to information, enhances patient understanding, and is also favored by users.

The results of the study also support the claim that information presented through a combination of visualization and text is more effective at communicating recovery information than current text dense formats. In fact, by following both the chunking principle and the dual code theory in this study, the information was meaningfully chunked and presented in both visual and written forms. Through the performance results, this was proven to help participants process the information more quickly and more accurately, that in turn should also reduce cognitive load. This is further supported by the fact that participants pointed out that information presented in small chunks, in a concise manner and with consistent visual elements, helped them easily process and understand information. The majority of participants mentioned that the layout of the new booklet design made them feel more reassured, confident, engaged and well informed. In terms of visualization, participants also noted that with the new design information was easier to remember due to the presence of visualization. Moreover, the majority noted that as the visuals are attractive and clear, they leave a more significant and lasting impression than just chunks of text. This is in addition to the fact that one single visual can connote a large amount of information at a glance and therefore require less time to process than reading the same information in text form.

In terms of future research, it would be of interest to explore the effects of visualization on long-term memory, which is an important factor for patients and a key factor for activating cognitive process (Del Re et al., 2016). Existing studies based on Paivio's (1991) dual-coding theory (i.e. combination of text and visual language) and chunking principle (i.e. combination of text and visual language divided into 3-4 units of information) have shown that visualization can improve recall and retention of information (Del Re et al., 2016; Tetlan and Marschalek, 2016; Hill et al., 2016; Latorre-Postigo et al., 2017). Moreover, long term-memory has a high capacity for storing detailed visual information (Brady et al., 2008). We would therefore propose the following research question – Does communication of bowel surgery recovery information, using a combination of text and visualization, improve recall and retention in comparison to text dense information?

Additionally, this study focused solely on users above the age of 50, as they are at a higher risk of developing bowel cancer. However, seeing that in recent years bowel cancer and bowel surgery cases are increasing amongst younger adults (the Guardian, 2019), the design outputs would benefit from being further validated with users between the ages of 20 and 50. Therefore, another question for future research is – Do the design outputs of this study enhance surgery recovery of younger patients? Or perhaps presenting the information through other multimedia mediums (e.g. motion graphics or mobile application) will be more appropriate to sustain engagement and cater for younger patient needs. First, because mobile

applications could provide holistic functions that promote patient involvement (Klasnja et al., 2010). Second, because younger generations (millennials and Gen Xers) use and depend highly on their smart phones (Jiang, 2018).

Another consideration for future research would be to investigate the potential of a motion graphics video on enhancing bowel surgery recovery. This was actually the second most selected companion output in our study. Animated videos such as motion graphics have been shown to have great beneficial impact on understanding, learning and recall (Berney and Betrancourt, 2016; Lonsdale and Liao, 2018). Moreover, in a previous study investigating the design of bowel preparation instructions for colonoscopy screening, a motion graphics video was found to be superior to a booklet and App for both younger and older generations (all following design principles and combining text and visualization) (Lonsdale et al., 2020). One of the reasons is because motion graphics allows the delivery of more detailed and step by step information, and in a more engaging way (Lonsdale et al., 2020). Another reason is that motion graphics require users to process the information on both auditory and pictorial channels which maximises their working memory capacity and reduces cognitive load (Mayer and Moreno, 2003; Koops van't Jagt et al., 2016; Latorre-Postigo et al., 2017). Moreover, their dynamic nature holds the users' attention (Choi, 2011), and their presentation is inclusive to all levels of literacy (Spinillo, 2017). This leads to another question for future research: Can a motion graphics video improve accessibility, understanding and recall of surgery recovery information over a combination of visualized and written information?

In conclusion, this is a thorough and in-depth study with high impact for bowel surgery patients, their families and caregivers, and the healthcare professionals involved in their recovery process. It is an important and novel contribution to the field of Information Design, not just in terms of research-based practical guidelines and empirical evidence, but also in terms of more tailored, inclusive and patient-centred research approach. Therefore, this research is also of high impact for design academics, researchers, practitioners and students. The benefits of following user-centred design methods in live healthcare scenarios through-out the entire research and design process, allows us to understand user needs and expecta-tions in depth. Moreover, this paper provides evidence in support of the need to be flexible, adaptable, creative and innovative in the use of existing methods that might need to be shaped to particular contexts and situations in order to maximise validity and fast applicabil-ity of the findings to real contexts (as it was the case of our 'within co-design' approach). In addition, this study is also an important contribution to the field of Healthcare, as our findings are also widely applicable to many (if not all) forms of healthcare and patient information. All in all, the final outputs are a successful example of research-based and user-centred design templates that communicate complex medical information in an effective way capable of promoting user understanding and engagement.

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