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Research Article

Evaluation of a Mobile Application Based on Enhanced Recovery After Surgery Recommendations to Support Patients Undergoing Colorectal Surgery: A Pilot Study

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Aims and Objectives: The aim is to evaluate the effect of a recently developed mobile application consisting of information, tasks, and gamification has had for patients undergoing colorectal surgery.
Background: Patients undergoing colorectal surgery are recommended to follow enhanced recovery after surgery (ERAS) guidelines. Yet, patients do not always follow ERAS recommendations. Patients express that they would like to have information about their course, that information material must be available at different times, and that too many papers and pamphlets can seem confusing and overwhelming.
Design: In this comparative nonrandomized pilot study, a mobile application is evaluated. Thirty-eight adult patients divided into intervention and control groups were included the study. Quantitative and qualitative methods were used.
Methods: Both groups answered questionnaires before discharge after surgery. Demographic data, The Preparedness for Colorectal Cancer Surgery Questionnaire Subsequently (PCSQ-PRE_24), intake of protein drink, and the degree of mobilization were collected. Four patients from the intervention group participated in a focus group interview. The STROBE cohort checklist was used.
Results: The study showed significant difference in favor of the intervention group in PCSQ-PRE_24: subtheme understanding and involvement in care processes $p = 0.043$ and total score $p = 0.034$ as well as intake of protein drink showed significant difference $p = 0.012$. There was no significant difference in terms of mobilization. The patients stated that the mobile application was easy to use and made them secure through their surgical procedure.
Conclusion: The results from this pilot study showed that patients undergoing colorectal surgery benefit from a tool in the form of a mobile application that can guide them through their surgical procedure.

Keywords: colorectal surgery; gamification; mobile application; multimethod study

Summary

- The application made the patients secure, and they felt better prepared and supported throughout the process, both pre- and postoperatively.

1. Introduction

Enhanced recovery after surgery (ERAS) guidelines were developed by Kehlet in the late 1990s [1] and have since been used widely in the world in patients who are part of a surgical procedure. The ERAS guidelines have recommendations in relation to mobilization, use of chewing gum, early nutrition, intake of protein drinks, and use of pep whistle and are designed to optimize the patient's postoperative course, including reducing the occurrence of complications, promoting rehabilitation, and shortening hospital stay [2, 3].

Since 2009, patients undergoing colorectal surgery at a university hospital in Denmark have received education on following ERAS recommendations. The teaching team,

comprising a nurse, a dietitian, and a physiotherapist, conducts these sessions approximately 1 week before the planned operation. During these two-hour sessions, patients and their relatives are informed about the rationale behind the recommendations and have the opportunity to ask questions. Despite providing patients with information and distributing brochures to support the taught themes, nursing staff have observed that patients do not consistently adhere to ERAS recommendations.

Over the past few years, numerous applications have been developed in order to support and inform patients during their experience with chronic diseases, surgical procedures, and medical treatments. Within the healthcare system, these applications serve as welfare technology solutions. The rationale behind introducing such solutions includes enhancing process coherence, promoting patient self-reliance, and ensuring greater security and safety. Research indicates that an application offering information about the surgical process and daily goal reminders contributes to higher patient satisfaction. Moreover, patients become more self-assured in their recovery journey and are motivated to regain lost functional capacity more rapidly [4–6]. In addition, an application can contribute to shorter hospital stays and fewer complications and thus lower total costs [7]. Reviewing the literature showed that an application involving gamification can be of greatest benefit to patients [8–10].

Gamification is a widely used method in apps to enhance motivation and learning among patients. Essentially, it involves incorporating game elements into nongaming contexts. The goal is to engage users of the application in specific actions, such as completing small tasks or achieving milestones, while rewarding desired behaviors with points, stars, or high-score lists. In healthcare contexts, gamification is increasingly employed to motivate patients in managing their illnesses and provide them with a sense of subjective control [10]. Interestingly, technological platforms that incorporate gamification tend to attract more frequent visits from patients compared to platforms without gamification [8].

Based on existing patient information, guidelines, and instructions for patients undergoing colorectal surgery, a mobile application was developed. This mobile application aimed to provide comprehensive information and guide patients through their surgical procedures. Additionally, elements from the ERAS recommendations were incorporated, with gamification playing a central role [3, 11]. To ensure user-friendliness in terms of content and layout, a workshop involving previously operated patients was conducted. The process line is shown in Figure 1. As a result, the application features three menus: "Front Page," "Tasks," and "Information" (Figure 2). The "Front Page" menu contains operation-related data, while the "Tasks" menu spans from 3 days before admission to 21 days after surgery. Tasks were designed to support patients and include film ex. How to get out of bed after the surgery, instructions, or text, for instance, reminders to buy painkillers, consume protein drinks before admission (Figure 3), and guidance on postoperative activities. The "Information" menu covers topics such as contact details, physical activity, bowel function, diet, breathing, pain management, wound care, sleep and rest, sexual health, and advice and guidance.

The hypotheses were that the mobile application would help patients track their progress and lead to increased adherence to ERAS recommendations. The primary aim of this study is to evaluate the effect of a recently developed mobile application consisting of information, tasks, and gamification has had for patients undergoing colorectal surgery. The secondary aim is to assess the application's user-friendliness, layout, and participant engagement.

2. Methods/Methodology

2.1. Design. In this pilot study, we used both quantitative and qualitative methods. Data were gathered from a control group that did not use the developed mobile application, as well as an intervention group that utilized the mobile application. Questionnaires and records of protein drink intake and mobilization were collected from both groups. Additionally, we assessed the application's user-friendliness, layout, and participant engagement through focus group interviews with participants from the intervention group.

2.2. Study Setting and Sampling. In this pilot study, a total of 40 patients were consecutively invited to participate. Twenty patients were assigned to the control group, while the remaining 20 were part of the intervention group. Data collection initially occurred in the control group and subsequently in the intervention group. Inclusion of participants took place consecutively from August 2022 to December 2023. As it was a pilot study, we planned with 20 patients in each group. In the department where the data were collected, approximately 70% of the patients have cancer and 30% have inflammatory bowel disease (IBD). Therefore, it was desirable to include 14 patients with a cancer diagnosis and 6 patients with a diagnosis of IBD. All participants received both oral and written information about the project during interviews at the Surgical Outpatient Clinic, where surgery planning occurs. Additionally, patients who expressed interest in participating were included during the patient school held the week before surgery. Informed consent was obtained from the first author during this process.

Inclusion criteria: patients were eligible for participation if they met the following criteria:

They were scheduled for colon or rectal surgery due to cancer or IBD.

They were admitted for elective surgery.

They were at least 18 years old.

They had attended the patient school.

They understood and read Danish.

For the intervention group, they were capable of using the mobile application.

2.3. Data Collection. Data on age, gender, and diseases were collected. To explore potential differences in patient involvement experiences, both the control and intervention

Figure 1: Process line.

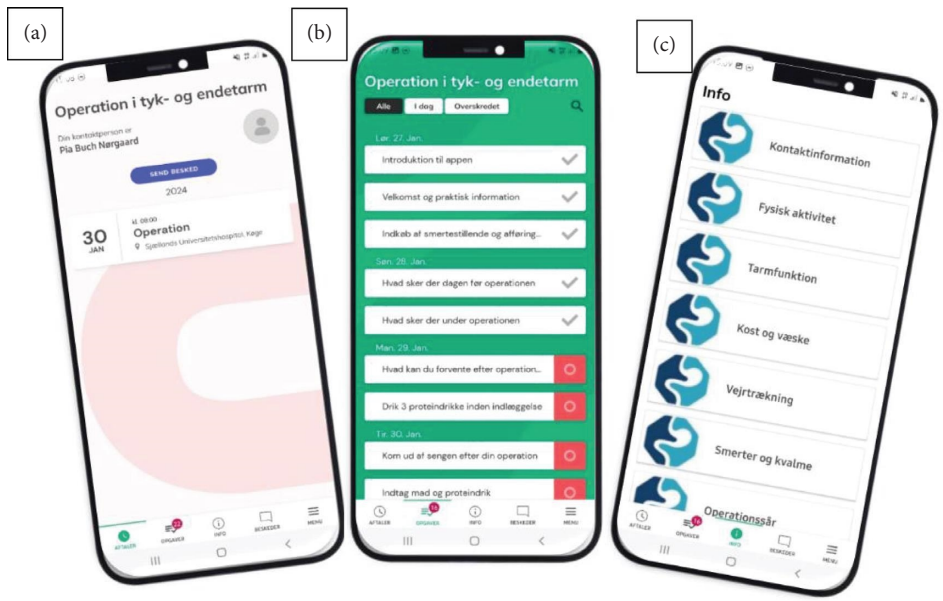

Figure 2: The application with three menus: a front page, tasks, and information. (a): Front page with the heading "surgery of the colon and rectum" and data for the operation. (b): Heading "surgery of the colon and rectum" and tasks to read as they appear in relation to the time of the operation with the ex. Buy pain killers, drink three protein drinks the day before admission, what happens during the operation, etc. (c): Information includes contact information, physical activity, bowel function, diet and fluids, breathing, pain and nausea, operation wound, sleep and rest, and sexual life.

groups received the Preparedness for Colorectal Cancer Surgery Questionnaire during discharge [12]. The PCSQ-pre 24 is a validated questionnaire that assesses patient-reported preoperative preparation, as well as information and support in the postoperative period. The PCSQ-Pre 24 questionnaire, developed in Sweden, was translated into Danish, back to Swedish, and finally to Danish. The Swedish author approved the final translation.

The questionnaire comprises 24 questions divided into four subthemes with the following headings: searching for and making use of information, understanding and involvement in the care process, making sense of the recovery process, and support and access to medical care. Participants responded using a four-point Likert-type scale, ranging from one to four where the lowest score means best preparation [12].

In addition, data were collected postoperative on the participants' mobilization and their intake of protein drinks.

2.3.1. Mobilization. All participants were given an actigraph (Octagonal Basic Motion Logger, Ambulatory Monitor Inc, New York, USA), which is a small wrist computer that measures activity and stores it on an internal memory. Data from the actigraph are given as a percentage of the activity that has lasted for more than 60 s [13, 14].

2.3.2. Protein Drinks. During admission, the care staff recorded in every shift how much protein drinks the patients consumed.

2.3.3. Ethical Considerations. The project was conducted in accordance with the principles of the Declaration of Helsinki. The protocol was registered in the current Region Research Register. Data were stored and processed in accordance with recommendations from the Data Protection Regulation and the Data Protection Act. A data processing agreement was drawn up with the company Emento in relation to the development, storage, and processing of data in the application. The Scientific Ethics Committee was asked if necessary for approval of the project and had no comment. Patients could withdraw their informed consent at any time. There was no risk associated with participation in the project. The group that tested the application would be able to obtain increased support during the hospitalization process. For both groups, there was a time consumption when answering the questionnaire. Likewise, there was in connection with participation in focus group interviews and time consumption.

2.3.4. Qualitative Analysis. Data from focus group interviews were analyzed using systematic text condensation

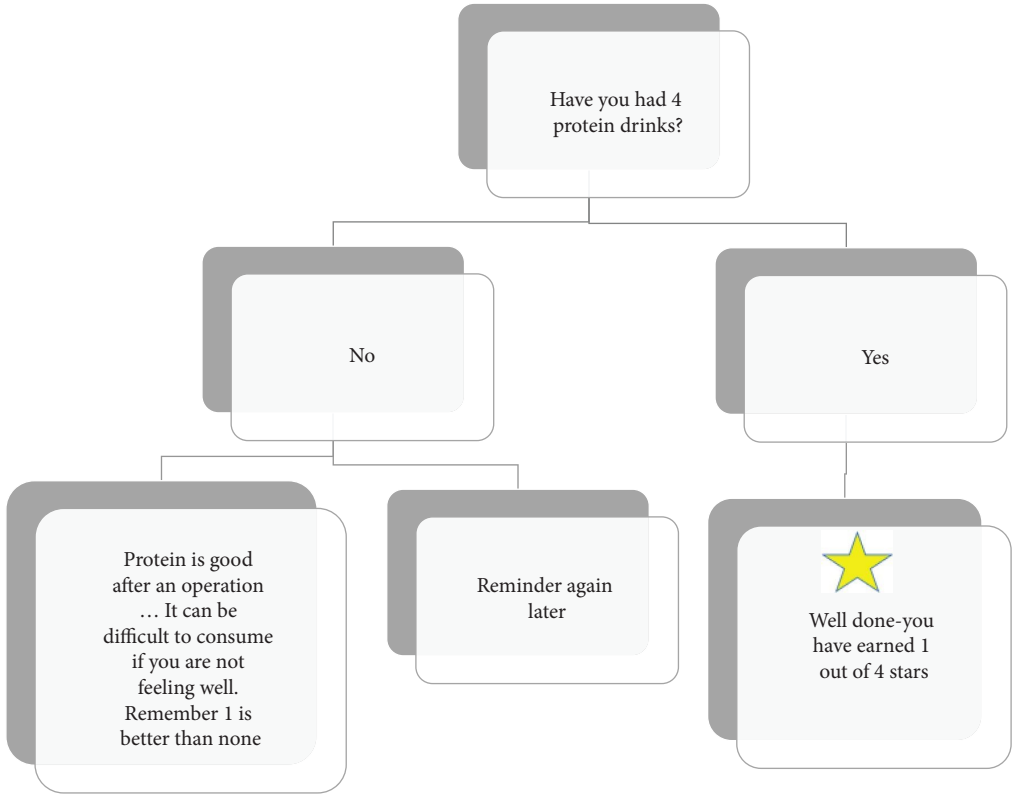

Figure 3: Example of pop-up notification and gamification about protein drink intake. Pop-up at 10 AM first postoperative day.

described by Malterud [15]. The analysis was carried out in four stages and both authors were involved in the analysis process. In the first step, the transcribed text was read through several times to gain an understanding of the participants' experiences of the app. During the second step, meaning-bearing units were identified, by finding the parts of the transcription that illuminated the purpose of the project. Each meaningful unit was then reformulated into code names. In the third step, codenames shared characteristics were organized into subthemes, after which the subthemes were categorized into main themes. During the fourth step, the pieces were reassembled by developing content descriptions for each main theme, which were supported by quotes from the transcription. When quoting, the informants were anonymized and referred to as informant 1, informant 2, etc.

2.3.5. Quantitative Analysis. The statistical analyses were carried out in SPSS Version 29. Descriptive statistics were used to describe characteristics in the control and intervention groups. The sample size was based on expected differences in the PCSQ total score. We anticipated a large effect size, with a difference at 30% between the intervention and control groups. Based on a significance level of 85% and a type I error rate of 0.05, a sample size of 18 in each group was required. When comparing the two groups' responses to the questionnaire, nonparametric Mann–Whitney was used. Mean (min. – max.) was used to present protein drink intake and mobilization, and nonparametric Mann–Whitney was used for comparison between the two groups. A p value of ≤ 0.05 was considered the level of significance.

3. Results

For the intervention group, 20 patients were included in the project, of which one patient dropped out due to postoperative complications, resulting in a group of 19 participants.

Nine patients were male. Age median was 59 years range 25–77, seven suffered from IBD, and 12 suffered from rectal cancer. In the control group, one patient did not answer the questionnaire before leaving the hospital, resulting in a group of 19 participants. Six patients were male. Age median was 57 years range 24–78, six suffered from IBD, and 13 suffered from rectal cancer. See Table 1.

For the focus group interview, five patients from the intervention group gave positive feedback about participation. One of the participants was prevented on the day, so the final number of participants in the focus group interview was four. The distribution was three patients with IBD and one patient with cancer. Two women and two men participated, with an age distribution of 49–73 years. The interview lasted 45 min. See Table 1.

3.1. Preparedness for Colorectal Cancer Surgery Questionnaire. In subtheme two understanding and involvement in care processes and in the total score, there was a significant difference between the intervention group and the control

Table 1: Descriptive presentation of participants in the project.

	Intervention group $N = 19$	Control group $N = 19$	Focus group* $N = 4$
Gender, male	9	6	2
Age, median (min–max)	59 (25–77)	57 (24–78)	63 (49–73)
Disease	7 IBD 12 rectal cancer	6 IBD 13 rectal cancer	3 IBD 1 rectal cancer

Abbreviation: IBD, inflammatory bowel disease.
*Participants from the intervention group.

group with $p = 0.043$ and $p = 0.034$, respectively, in favor of the intervention group. Apart from these two subthemes, there was no significant difference. See Table 2.

3.2. Protein Drinks. The analysis of the difference in the total intake of protein drinks showed a tendency for the intervention group to drink more protein drinks than the control group ($p = 0.09$). On the day after surgery (POD1), the intervention group drank more than twice as many protein drinks as the control group, with a significance of $p = 0.012$. See Table 3.

3.3. Mobilizing. There was no statistically significant difference in mobilization between the two groups. However, there is a tendency for the control group to have been more mobilized than the intervention group. See Table 3.

3.4. Focus Group Interview. The analysis of the focus group interview identified the five main themes: (1) use, (2) design, (3) gamification, (4) information, and (5) accessibility. Under the main themes, 10 subthemes were found which described the participants' experience of the application's content, layout, and usability (Table 4).

3.5. Application. The informants said that they used the application before, during hospitalization, and after discharge. They said that it was appropriate to have access to the application a few days before admission, so that they had the opportunity to find answers to any questions and doubts that had arisen before admission.

> "I think it was very appropriate that it came a little earlier, so that you could just prepare the last few things" (informant 4).

The informants said that they used the mobile application during hospitalization, where it served as a reminder of what had to happen and what they had to remember to do. In addition, they also had the opportunity to continuously find information if they had questions and were thereby not dependent in the same way on asking the staff in case of doubt.

> "I didn't have to constantly get hold of a member of staff to ask, then I could just go in and have a look. I actually think it was really good. I think they think so too. That I don't pull the strings all the time" (Informant 1).

Access to the mobile application was completed 3 weeks after surgery. This timeframe, which the informants expressed, was too short, as they used the app after discharge when questions arose, e.g., in relation to diet and liquid or bowel function.

> "I think it was nice when there were some things that you don't remember like that. Yes, it would have been nice if you had stayed a little longer" (Informant 1).

Another possibility of use the informants also mentioned was that they showed the mobile application to relatives, in order to better involve them in the course of the operation in relation to what was to happen, but also what tasks they had to carry out.

> "I have shown it to my wife as well. She herself had an operation three years ago and had a stoma made. Back then we could have used it because so many things happened. It would have been really good if I could have also been involved a little in it to understand what it was all about, it was a bit difficult to do that" (Informant 1).

3.6. Design. The informants thought that the mobile application's layout was user-friendly and that they could easily find the information they needed. Only one of the informants found it a little difficult to click on the tasks, but despite that she still found the app useful and informative.

> "So I think it was easy to find your way around... The thing about being able to go back and watch those informational film and things like that, it was, it was really good. You can't remember everything, and I think that was easy to find" (Informant 2).

Based on the informants' statements, it was an advantage that the mobile application provided information both via text and via film. One of the informants had only read the text, while the others had seen both the film and read the text.

> "I have used both. So in my world, it's a huge advantage to have both, because you remember better when you get it in several different ways, so I might have seen the film the first time, and then I've read the text the second time I have gone into it. Or vice versa, that is, it's a huge advantage, I think so" (Informant 2).

Table 2: Results from preparedness for the Colorectal Cancer Surgery Questionnaire.

	Intervention group ($n = 19$)	Control group ($n = 19$)	p
1. Searching for and making use of information	6.81 (1.72)	8.00 (2.48)	0.126
2. Understanding and involvement in the care process	9.06 (2.19)	11.56 (4.34)	0.043
3. Making sense of the recovery process	7.06 (2.44)	8.00 (2.83)	0.313
4. Support and access to medical care	12.88 (3.60)	13.33 (2.77)	0.697
Total score	36.25 (6.53)	43.50 (8.76)	0.034

Note: Value in mean (SD).

Table 3: Ingestion of protein drink and mobilization.

	Intervention group, $n = 19$	Control group, $n = 19$	p
Protein drink, mean (min–max) [95% CI]			
Total	0.80 (0–3) [0.58; 1.11]	0.53 (0–2) [0.43; 0.89])	0.09
*POD0	0.38 (0–2) [0.045; 0.705]	0.32 (0–1) [0.08; 0.56]	0.79
**POD1	1.41 (0–3) [1.02; 1.92]	0.66 (0–2) [0.26; 1.05]	0.012
***POD2	0.54 (0–2) [0.14; 0.94]	0.59 (0–2) [0.22; 1.00]	0.86
Mobilization◊ mean (SD)			
Total	75.56 (30.00–98.96)	78.26 (24.17–97.50)	0.22
POD0 evening	65.85 (30.00–98.48)	64.67 (24.17–90.81)	0.87
POD1 day	76.28 (49.90–94.18)	81.37 (58.27–95.43)	0.23
POD1 evening	76.37 (57.17–98.96)	81.98 (51.61–96.67)	0.19
POD2 day	83.04 (67.78–98.54)	84.13 (69.09–97.50)	0.76

◊Mobilization, data from the actigraph, expressed as the percentage of activity lasting more than 60 s.
*POD0 = day for operation.
**POD1 = day one after operation.
***POD2 = day two after operation.

3.7. Gamification. The informants thought that the pop-up messages were good, and they helped them to remember the tasks of the day. In particular, protein drinks, mobilization, and pep whistle were mentioned. In addition, the pop-up messages made them feel more confident about what they had to do after the operation, e.g., that it was okay to move around and take a walk.

> "Where I used it the most was when I got those notifications. Now you must remember it, and now you must remember it. It was quite nice, I think" (Informant 3).

The mobile application's tasks and including the use of gamification reminded the informants of what they had to do. The informants believed that it pushed their conscience, and thus, they got the tasks done.

> "So if you don't, you get a bad conscience. I don't remember that it kind of pushed me, but I think it did" (Informant 2).

In addition, gamification has also meant that the informants found it exciting to use the application and click on the various tasks.

> "I was at the hospital two or three days and then I used the application, it was exciting to be able to sit and look through it" (Informant 4).

3.8. Information. The informants generally thought that the information contained in the mobile application was informative and provided answers to most questions.

> "If you don't know better, I think the information there is really good. I think it was really good. I think it was very informative" (Informant 1).

The informants thought that there was a good match between the information they had received at patient school and the information that was in the mobile application. They did not think that there was anything that could be dispensed with, as they thought it was nice to get information first at patient school and then have the opportunity to find the same information in the app.

> "Yes, there is definitely some overlap in the information. There has to be that. Something you might not be able to remember completely, you could just brush it up" (Informant 2).

The informants had not needed any further information apart from elaboration on fasting time and exercise/activity after discharge.

> "I miss a bit in relation to when you had to fast from. It said that I had to fast, I think it said the day before. But I could have gotten a date" (Informant 4).

Table 4: The analysis process of the focus group interview.

Informant	Meaning-bearing unit	Code name	Subtheme	Main theme
1	I think that it was nice when there were some things that you do not quite remember. . ., it would have been nice if you had been there a little longer after the operation	Nice to be able to look up the application for a longer time	Duration	Use
2	I probably used it mostly before I had surgery, not so much after	Use before surgery	Point in time	Use
1	Well, I actually think it was good too, the application was well-built, I think it was easy to find your way around	Easy to find around the application	Navigation	Design
2	. . . It is a huge advantage that there are both because you remember better when you get it in several different ways, so I might have watched the video the first time, and then I have read the text the second time . . .	Good with both text and video	Method for communications	Design
3	I used it mostly when I got those notifications. Now you must remember to remember this, now you must remember that. It was quite fine, I think.	Good to get notifications	Notification	Gamification
4	I was at the hospital two or 3 days and then I used the application, it was exciting to be able to sit and look through it	Pop-up	Gamification	Gamification
4	I might miss a bit that it said what you could eat. But if it was unlimited, then of course, it does not matter	Missing information about what to eat	Uncertainties	Information
1	If you do not know better, I think the information there was really good	The Information is good	Information	Information
2	Precisely because I was discharged quickly, it was nice that I could just go in and see, well, of course I have to remember these things.	Nice with the application that guides you at home	Peace of mind	Accessibility
1	The thing that I had doubts about and could tell my wife that she should just take it easy because it says here on the phone that it should be like that and, and it was I think it was pretty good.	Provides information and creates peace of mind for both patient and relatives	Peace of mind	Accessibility

3.9. Availability. The informants said that it was nice to have information available all the time and at hand. It created a sense of security around the operation and the aftermath.

> "Precisely because I was discharged quickly, it was nice that I could just go in and see, well, of course I have to remember these things" (Informant 2)

In addition, the informants also said that it was great that the information was digital, as that way you always had the information with you everywhere, whereas information on paper is left at home or maybe even lost.

> "After all, you always have that little thing [mobile phone] with you and can check from time to time, you don't need those papers with you. . . It may well be that I also got the papers you got. I cannot remember it. But they have probably gone" (Informant 1).

4. Discussion

It appears that the mobile application positively affects patients' experience during surgical procedures. The intervention group reported greater preparation, support, understanding, and involvement in their care process. This aligns with findings from Niburski et al. meta-analysis, which showed higher satisfaction and reduced anxiety when using shared decision-making. Additionally, patients in the focus group interview found the application informative and reassuring. A study by Renna et al. highlighted patients' desire for information in alternative formats and the lack of electronic access to information [16].

The focus group interview highlighted that the mobile application was used at various times and that its combination of film and text-based information was advantageous. This aligns with existing literature emphasizing the significant impact of health literacy on patients' understanding and experience of information related to their care process [17].

The focus group interview highlighted that gamification within the mobile application serves as a motivating factor for adhering to ERA's recommendations. Specifically, the intervention group consumed more protein drinks than the control group, demonstrating this positive impact. This aligns with findings from a systematic review, which indicates that gamification positively influences health and well-being. By breaking tasks into partial components and providing rewards, patients become more engaged in their own care process, fostering commitment and potentially reducing the need for healthcare service [9].

The focus group interview revealed that despite gamification and discussions about the benefits of adhering to ERAS recommendations, mobilization tended to be lower in the intervention group. This apparent contradiction may be explained by the department's relocation during the project, potentially affecting data related to mobilization. Notably, data from the control group were collected from patients in 2-bed or 4-bed rooms with access to a dining/living room. In contrast, the intervention group consisted of patients in solitary confinement rooms without such amenities. These single rooms have their own toilet/bath facilities and seating areas, reducing the need to leave the bedroom. Recent studies suggest that patients in solitary confinement exhibit decreased mobility [18].

5. Strengths and Limitations

Despite the limited sample size in this pilot study, the quantitative results should be cautiously generalized. The study benefits from a well-distributed representation across age, gender, and disease. Additionally, the use of anonymous questionnaires and non-self-reported data (such as protein drink intake and mobilization) strengthens the findings.

The qualitative results may be affected by the uneven distribution of disease among focus group participants. Patients with IBD have a longer awareness of their condition compared to cancer patients. Consequently, patients with IBD might have had more time to engage with the app, while cancer patients may be preoccupied with thoughts related to their recent diagnosis. Further investigation through additional interviews could provide valuable insights.

The study was not randomized, which would have been preferable. Without randomization, there is a greater likelihood that unmeasured variables—such as patient motivation, baseline health status, or staff engagement—may have differed between the intervention and control groups, potentially influencing the outcomes. However, it was not feasible to blind participants to whether they were in the control or intervention group. At the time the study was initiated, the department had four-bed rooms where patients frequently discussed their treatment experiences. As a result, the application could easily have been shared with patients in the control group.

It is possible that the staff's awareness of the study may have influenced their care of the patients. However, this increased attention would likely have been present in both groups, meaning that any change in care would have affected both the control and intervention groups. Furthermore, as the department was already working in accordance with ERAS principles, it is considered that the awareness did not influence data collection or the study results.

Another potential weakness of the qualitative results is the dual role of the first author as both the mobile application developer and the interviewer during the focus group. Participants might have hesitated to criticize the app due to this connection. However, it is worth noting that during the interview, participants were encouraged to provide feedback and suggest improvements.

6. Recommendations for Practice

This pilot study leads to several research topics. One topic could be to conduct the same study with several participants. Another topic could be when patients have a single room, how can nurses support patients' motivation to move? Finally, it could be relevant to see if the effect of the mobile application if it is a part of the offer of information in the

department. A larger randomized controlled multicenter trial is recommended to confirm the findings.

The department's management decided to offer the mobile application to patients in colorectal course the next year. Following this, an evaluation will determine whether the mobile application should become a standard offering for patients in colorectal course. If the 1-year evaluation yields positive results, there are plans to develop a similar mobile application for other diagnostic groups within the department.

7. Conclusion

The findings of this pilot study indicate that patients undergoing colorectal surgery derive significant benefits from a mobile application that serves as a support tool, guiding them through their surgical journey. The mobile application provides readily accessible information and timely reminders about essential tasks at various stages during the surgical process. Patients reported feeling more secure, better prepared, and well-supported both before and after the surgery.

The STROBE cohort reporting guidelines was used [19].

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Conflicts of Interest

The authors declare no conflicts of interest.

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