

Home to Stay: An Integrated Monitoring System Using a Mobile App to Support Patients at Home Following Colorectal Surgery

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Abstract

Background: Patients undergoing colorectal surgery are vulnerable during their transition from hospital to home and require increased support following discharge from hospital. Study objectives were to perform an initial assessment of patient uptake, outcomes, and satisfaction with an integrated discharge monitoring system called Home to Stay. **Methods:** The intervention was an integrated discharge monitoring system that uses a mobile app platform. Patients downloaded the app prior to discharge from hospital and received a Daily Health Check day #1 to #14, #21, and #30. Patient responses were accessed by the health-care team via secure web site, and extreme responses were “flagged” to indicate that a follow-up telephone call was necessary. Primary outcomes were patient uptake, Quality of Recovery scores and satisfaction with the program. Secondary outcomes were 30-day emergency room (ER) visits and readmissions. **Results:** One hundred and thirty-two patients were invited to participate and 106 accepted. Of these, 93 used the app at least once. The mean overall score on the Quality of Recovery Scale increased significantly from day 1 to day 14. Patient satisfaction with the app was high, with 92% of patients reporting overall satisfaction as good or excellent. The 30-day readmission rate was 6% and was lower than the 30-day readmission rate of 18% reported for the 4 months prior to the start of the study. **Conclusions:** The Home to Stay Program to support patients at home after colorectal surgery is feasible with high patient uptake and satisfaction. This program has the potential to reduce 30-day readmissions, however further studies are required.

Keywords

colorectal surgery, mobile application, postoperative recovery, patient satisfaction

Introduction

Patients undergoing colorectal surgery are vulnerable during their transition from hospital to home. They are faced with pain management issues, significant changes in bowel function and diet, and occasionally complex wound and stoma care needs (1–4). Colorectal readmission rates are high, at 10% to 27% (5,6), translating into high costs for the health-care system: In the United States, the cost of colorectal readmissions is estimated at US\$300 million annually (7). Up to 30% of colorectal surgery readmissions are for dehydration, stoma-related complications, and surgical site infections, representing a subgroup of readmissions which are feasibly preventable (6).

Recently, our group held a series of patient engagement meetings and one of the key issues identified by our patients was the need for increased support following discharge after colorectal surgery. Although previous transitional care

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interventions have included the use of telephone and in-person follow-up (8–11) and have been shown to be effective (12,13), they require full time, dedicated staff, making these programs costly and difficult to sustain. Technology is increasingly being used to overcome these human resource challenges and has the added potential to be more cost effective and sustainable. According to a 2016 national survey, smartphone ownership among Canadians in 2016 has reached 76% (14). With the growing pervasiveness of smartphone use in the Canadian population and elsewhere, it is reasonable to anticipate that a majority of colorectal surgery patients will have access to and proficiency with the use of a smartphone. Therefore, our group developed an integrated monitoring system using a mobile app platform, called Home to Stay, to support patients at home following colorectal surgery. We selected the mobile app platform because it allowed for real-time monitoring of patients' daily progress and early intervention in patients not progressing as expected at home.

The objective of this study was to perform an initial assessment of patient uptake, outcomes, and satisfaction with the Home to Stay Program and use this information to evaluate if the Home to Stay system should be fully adopted into clinical practice.

Methods

Study Design and Patient Population

The study design was a prospective, cross sectional survey to assess the patient uptake, outcomes, and satisfaction with the Home to Stay system. The study was approved by the Research Ethics Board prior to the start of the study. The inclusion criteria for the study were: (1) any patient undergoing elective, colorectal surgery for benign or malignant disease; (2) English-speaking; (3) 18 years or older; and (4) having a compatible device (iphone or Android smartphone, laptop, or desktop computer). Patients were excluded if they had (1) undergone emergency surgery or (2) were being discharged to a nonhome destination (rehabilitation, nursing, or long-term care facilities). Patients who met inclusion criteria were invited to participate in the study, and informed consent was obtained. The study was conducted at a single, academic high-volume colorectal surgery center (Mount Sinai Hospital, Toronto, Ontario, Canada).

Intervention

The intervention was the Home to Stay Program using a mobile app platform that was developed and specifically customized to the needs of patients who have undergone colorectal surgery. The app is a compatible, smartphone and tablet operating system including iOS and Android, as well as a web-based platform for use on a computer. The app took approximately 3 months to develop and is compliant with the Health Insurance Portability and Accountability Act (HIPAA) and the Personal Health Information Protection

Act (PHIPA). The features on the app include (1) a "Daily Health Check," for the patients to report on their postoperative recovery; (2) picture taking capability for patients to photograph their incisions and stoma to share with their health-care providers; and (3) educational information on postoperative care and self-management at home. The Daily Health Check was completed by the patients on day #1 to day #14, #21, and #30 at home following discharge from hospital. The Daily Health Check consisted of a series of questions specific to colorectal surgery, as well as the Quality of Recovery (QoR-15) questionnaire (15,16). The QoR-15 is a validated instrument developed to measure the quality of recovery following discharge after surgery and is measured on a 15-item instrument with each item rated on an 11-point numerical rating scale (for positive items, 0 = "none of the time" to 10 = "all of the time"; for negative items the scoring was reversed; maximum score 150). Overall, the Daily Health Check consisted of 27 questions for patients with no stoma and 33 questions for patients with a stoma. The time to complete the Daily Health Check in the pretesting phase was roughly 6 minutes, with completion presumed to become faster for patients with repeated entries. After completing the Daily Health Check, the patient received a list of recommendations tailored to their responses including relevant educational modules, to contact the surgical team, or in urgent cases to go to the closest emergency room (ER). The patients' responses were monitored daily by 2 physician assistants (PAs) on the surgical team between the hours of 8 AM to 2 PM Monday to Friday, via a secure web site. Any patient responses in the extreme ranges were automatically "red flagged" and notified the PA that a follow-up telephone call was required for further assessment. An example of a "red flag" was if a patient reported an 8 of 10 (or higher) in response to questions pertaining to pain levels, vomiting, chest pain, or difficulty breathing. Daily reminders were sent to each of the participants to encourage them to complete each of the Daily Health Checks. On postdischarge day #30, participants were also sent a satisfaction survey to complete, which was a nonvalidated questionnaire developed by the investigative team and included 5 questions that were rated on a 5-point Likert scale (see Table 1). In general, it took the PA approximately 5 minutes to recruit a patient for the study and assist with downloading the app to the patient's mobile device. Patients were provided with an instruction sheet on how to use the app, and technical support was available on a 24-hour basis.

Study Outcomes

The primary outcomes for the study were patient (1) level of uptake, (2) overall score on the QoR-15, and (3) satisfaction with the Home to Stay Program. Level of uptake was defined as the proportion of patients who submitted data at least once from postdischarge day 1 to 14. Quality of recovery was evaluated with the overall and domain scores on QoR-15. Patient satisfaction was assessed using a

Table 1. Satisfaction Survey Questions and Results.

Survey Questions, n (%)	1 Strongly				5 Strongly	
	Agree	2 Agree	3 Neutral	4 Disagree	Disagree	Missing
Overall, I had an excellent experience using the mobile app	15 (63)	7 (29)	1 (4)	1 (4)	0	0
I would recommend the mobile app to other patients having this surgery	19 (79)	3 (13)	2 (8)	0	0	0
The mobile app helped me feel more confident about managing my recovery at home after surgery	10 (42)	9 (38)	3 (13)	1 (4)	0	1 (4)
The mobile app helped me feel less worried after surgery	7 (29)	11 (46)	5 (21)	0	0	1 (4)
I felt reassured that someone from my health-care team was monitoring my mobile app results	16 (67)	5 (21)	3 (13)	0	0	0

satisfaction survey sent with the final Daily Health Check on postdischarge day #30.

Secondary outcomes included the number of 30-day ER visits, ER visits avoided, and 30-day readmissions; 30-day ER visits were defined as the proportion of patients reporting an ER visit to any emergency department within 30 days of discharge, and 30-day readmission rate was defined as the proportion of patients reporting readmission to any acute care hospital within the 30 days following discharge from their index hospital stay. ER visits avoided was defined as cases in which the surgical team arranged for a direct readmission for the patient so that an ER visit was avoided.

Specific complications included ileus, wound infection, stoma complication, dehydration, bowel obstruction, anastomotic leak and/or intraabdominal abscess, and length of stay.

Data Analysis

Since this was a descriptive study, a sample size of 100 was selected to ensure a 95% confidence interval of at least $\pm 9.8\%$ for any given proportion of patients. Descriptive statistics were used to report means for continuous data and frequencies and proportions for categorical data. Comparisons between the mean QoR-15 scores between post-operative day (POD) 1 and POD14 were made using repeated measures linear regression. A P value of $<.05$ was considered statistically significant. Statistical testing was performed using Stata software (StataCorp. Stata Statistical Software: Version 14.2. College Station, TX: StataCorp LP. 2015).

Results

Between November 2016 and April 2017, 132 consecutive patients who met the inclusion criteria were invited to participate in the study, of which 106 accepted and were enrolled. Of the 26 patients who declined, 7 (27%) were unable to participate due to lack of a compatible device. The remaining 19 patients had a compatible device but were not interested in participating in the study due to time constraints and inconvenience. Ninety-three patients ultimately logged into and used the app at least once, for an overall participation rate of 88% (93/106). Of these, 82 patients used the app at least once in the first 14 days at home, had complete data for both primary and secondary outcomes, and were included

in the analysis. For the remaining 11 patients, 9 of them used the app only after postdischarge day #14 and 2 patients had technological problems preventing use of the app. None of the patients completed all requested Daily Health Checks (ie, day #1-#14, #21, and #30). The participant demographics are shown in Table 2. The median age of the participants was 43 years, 63% had inflammatory bowel disease, and 40% had a laparoscopic or laparoscopic assisted procedure. Nearly half (47%) of the participants had a new stoma created, and the median length of stay was 6 days (interquartile range 4-8 days). Surgical complications are also shown in Table 2. The most common complication was superficial surgical site infection (22%), followed by stoma-related issues (17%).

During the first 14 days at home, the mean number of app entries per participant was 7.2 (range 1-14). The proportion of patients who completed Daily Health Checks on the app varied over the 14 days from 41% to 64%, with highest usage by participants occurring between days 2 to 8 after discharge (Table 3). Each participant's responses prompted on average 2 call backs per participant (range 0-9) and 0.2 warnings per participant to go to the ER. On average, each PA spent 1.5 hours per week on monitoring duties and follow-up phone calls related to the mobile app.

The mean overall score on the QoR-15 increased significantly from postdischarge day #1 to #14 from 112.0 to 120.0 ($P < .001$; Table 4). Changes in scores from postdischarge day #1 to #14 were significant for 6 of the 15 specific domains including able to look after personal toilet and hygiene unaided ($P < .04$), getting support from hospital doctors and nurses ($P < .03$), able to return to work or usual home activities ($P < .001$), feeling comfortable and in control ($P < .04$), having a feeling of general well-being ($P < .001$), and feeling worried or anxious ($P < .04$; Table 4).

Based on the participants' responses to the Daily Health Checks, a total of 17 recommendations were generated instructing the patient to visit the ER. Overall, 15 (18%) participants visited an ER within 30 days of discharge, however these cases did not necessarily coincide with recommendations on the Daily Health Checks. Five (6%) participants were readmitted to hospital within 30 days of discharge. Reasons for readmission in these 5 participants included bowel obstruction (1), anastomotic leak/abscess (2), hematoma (1), and wound infection (1). Of these 5

Table 2. Demographic and Clinical Characteristics.

Variables	Median (IQR)	n (%)
Age in years	43 (33-55)	
Sex		
Male		46 (56)
Female		36 (44)
Comorbidities		
None		47 (57)
Coronary artery disease		1 (1)
Hypertension		4 (5)
Diabetes		3 (4)
Other		27 (33)
Diagnosis		
Neoplasm/malignancy		19 (23)
Inflammatory bowel disease		52 (63)
Diverticular disease		3 (4)
Other		8 (10)
Immunosuppression		
Yes		11 (13)
No		71 (87)
BMI	26.0 (22-35)	
Surgical approach		
Laparoscopic		33 (40)
Open		43 (53)
Converted		6 (7)
Operation performed		
Partial colectomy		18 (22)
Total colectomy		17 (21)
Low anterior resection		8 (10)
Abdominoperineal resection		3 (4)
Ileal pouch anal anastomosis		10 (12)
Other		26 (31)
Length of stay in days	6 (4-8)	
Stoma type		
Ileostomy		37 (45)
Colostomy		2 (2)
Stoma duration ^a		
Temporary		21 (54)
Permanent		16 (41)
Unknown		2 (5)
Complications		
None		47 (58)
Ileus		1 (1)
Wound infection		18 (22)
Stoma complication		14 (17)
Dehydration		6 (7)
Anastomotic leak		1 (1)
Obstruction		2 (2)
Other		2 (2)
ER visits		15 (18)
ER visits avoided ^b		3 (4)
Readmissions		5 (6)
FP visits		20 (24)

Abbreviations: FP, family physician; ER, emergency room; IQR, interquartile range.

^aPercentages referring to proportion out of 39 new stomas.

^bCases of facilitated readmission for a participant, bypassing ER.

participants, the Daily Health Checks facilitated direct admission for 3 participants so that an ER visit was avoided.

Table 3. Completed Daily Health Checks From Postdischarge Day #1-#14.

No. Days After Discharge	Number of Completed Health Checks (%)
1	32 (40.5)
2	50 (61.7)
3	52 (64.2)
4	44 (54.3)
5	38 (46.9)
6	46 (56.8)
7	43 (53.1)
8	48 (59.3)
9	40 (49.4)
10	36 (44.4)
11	35 (45.7)
12	39 (48.1)
13	41 (50.6)
14	34 (42.0)

In all, 26% (24/93) of participants completed the satisfaction survey on postdischarge day #30. Overall, 92% reported that they strongly agreed or agreed that their overall experience with the Home to Stay Program was excellent and would recommend the Home to Stay Program to future patients undergoing colorectal surgery; 80% of participants felt that the mobile app helped them feel more confident about managing their recovery at home, 75% reported that the app helped them feel less worried after surgery, and 88% felt reassured that someone from the health-care team was monitoring their results.

Discussion

This initial assessment of the Home to Stay Program showed high patient uptake and patient satisfaction. The Home to Stay Program also allowed us to prospectively track the quality of recovery on the QoR-15 and successfully identify patients at risk and intervene in a timely fashion. Notably, we found that the 30-day readmission rate with the Home to Stay Program was 6%, which was much lower than previously reported in the literature and compared to the preceding 4 months prior to the introduction of the Home to Stay system at our center which was 18%.

We had a high uptake and usage of the mobile app, and only a few patients were not able to participate due to lack of a personal device. Although some previous studies using mobile app technology have reported uptake of less than 50% (17,18), most of these apps were solely educational and not interactive. One of the main reasons that our patients used the Home to Stay Program was that they knew their progress was being monitored by their health-care team. This made them continue to feel connected to their health-care team and hospital and decreased anxiety and increased confidence at home following discharge. A recent systematic review of perioperative mobile health technology identified 10 studies, of which 8 were feasibility studies and 2 were

Table 4. Quality of Recovery-15 Scores on Postdischarge Day #1 and #14.^a

QOR-15 Item ^b	Day 1	Day 14	Mean Change ^c	P Value
N	34	35		
1 Able to breathe easily	8.9 ± 2.1	9.1 ± 2.0	0.3	.10
2 Been able to enjoy food	7.7 ± 2.1	8.4 ± 1.9	0.8	.09
3 Feeling rested	7.0 ± 2.4	7.2 ± 2.2	0.6	.37
4 Have had a good sleep	6.4 ± 2.2	6.9 ± 2.0	0.5	.04 ^d
5 Able to look after personal toilet and hygiene unaided	9.1 ± 1.9	9.2 ± 1.3	0	.04 ^d
6 Able to communicate with family or friends	9.4 ± 1.0	9.4 ± 1.1	0	.73
7 Getting support from hospital doctors and nurses	7.7 ± 3.5	8.6 ± 1.9	0.9	.03 ^d
8 Able to return to work or usual home activities	2.7 ± 3.0	4.6 ± 3.1	1.8	<.001 ^d
9 Feeling comfortable and in control	6.3 ± 2.5	7.1 ± 2.2	0.8	.04 ^d
10 Having a feeling of general well-being		7.4 ± 2.1	1.4	<.001 ^d
11 Moderate pain	2.8 ± 2.3	2.7 ± 2.4	-0.1	.05 ^d
12 Severe pain	0.9 ± 1.4	1.2 ± 2.1	0.3	.65
13 Nausea or vomiting	0.9 ± 1.3	0.9 ± 1.8	0	.11
14 Feeling worried or anxious	2.9 ± 2.8	1.9 ± 2.1	-1.0	.04 ^d
15 Feeling sad or depressed	1.7 ± 2.4	1.1 ± 1.6	-0.6	0.41
Total score	112.0 ± 17.6	120.0 ± 18.8	8.0	<.001 ^d

Abbreviations: SD, standard deviation; POD: post-operative day.

^aData are presented as mean ± SD.

^bQOR-15 = Quality of Recovery-15 scale; each item scored 0 to 10, where 0 = none of the time and 10 = all of the time.

^cMean change from POD1 to POD14.

^dSignificant.

randomized controlled trials (19). Most of these studies were small prospective series including 20 to 60 patients. Three of these studies were in general surgery patients (18,20,21), and while all 3 used a symptom tracker and photosharing function, only one study included ongoing monitoring and follow-up based on patient responses (21).

One of the other advantages of the Home to Stay Program is that the health-care team is able to monitor the patient's daily progress at home. The participant QoR scores in this study were quite reassuring showing low levels of pain, nausea and vomiting, and anxiety. These data are helpful to both patients and physicians to begin to understand a "normal" trend in recovery in the first 14 days at home following colorectal surgery. This information can be used to reassure patients who are following the "normal" trend as well as identify patients not following these "normal" trends earlier so that the health-care team can intervene early and avoid potentially preventable 30-day ER visits and readmissions. The ability to easily capture and understand the normal trends in patient recovery at home is a unique feature of the Home to Stay Program. To date, there has been relatively little investigation into trends in recovery at home following surgery since this was a relatively labor intense process that included daily telephone surveys or home visits (22).

In addition to the high uptake rate and satisfaction with the Home to Stay Program, our group was surprised to find that our 30-day readmission rate to any hospital was 6%, which was much lower than the 30-day readmission rate of 18% at our center reported in the 4 months leading up to the introduction of the Home to Stay Program. Therefore, while our data are limited due to lack of concurrent controls, they provide compelling data to suggest that the Home to Stay Program may considerably reduce 30-day readmission rates

following discharge. This reduction in 30-day readmission rate is particularly impressive given the high proportion of new stoma patients (47%) who are at much higher risk of readmission than those without a new stoma (23). Although more rigorous evaluation is necessary, the reduction in readmission rate and the 0.78 hours of PA required to follow each patient for 30 days postdischarge suggest that the cost effectiveness of the Home to Stay Program is quite favorable.

The main limitation of this study was the low response rate on the 30-day satisfaction survey and suggests that monitoring system is probably only necessary for 14 days. However, the focus group following the pilot project highly supported the results of the survey in that patients were highly satisfied with the app as well as the 14-day time frame. Furthermore, since this was a descriptive study, there was no contemporary comparison group. Currently, our group is conducting a randomized trial to evaluate the effect of the Home to Stay Program on patient recovery and satisfaction and as well as 30-day ER visits and readmissions.

Conclusion

Our Home to Stay Program was highly successful based on the high participating rate and patient satisfaction scores. The decrease seen in the 30-day readmission rate suggests that this program may be a cost-effective strategy to improve the patient experience. Future controlled clinical studies will be required to confirm these findings.

Authors' Note

CK, AE, and EK contributed to the conception and design of the work; the interpretation of data for the work; and drafting and

revising the manuscript. SS, SR, AG, and RS contributed to the acquisition and interpretation of the data. CK contributed to the analysis of the work. All authors contributed to final approval of the version to be published. Poster presented at Canadian Surgery Forum; Victoria, BC, Canada; September 14-16, 2017. Poster presented at Annual Scientific Meeting (ASCRS); Nashville, TN; May 19-23, 2018.

Declaration of Conflicting Interests

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