BJA

British Journal of Anaesthesia, 119 (5): 1030–8 (2017)

doi: 10.1093/bja/aex331
Quality and Patient Safety

Evaluation of postoperative recovery in day surgery patients using a mobile phone application: a multicentre randomized trial

M. Jaensson*, K. Dahlberg, M. Eriksson and U. Nilsson

Faculty of Medicine and Health, School of Health Sciences, Örebro University, 701 82 Örebro, Sweden

*Corresponding author. E-mail: maria.jaensson@oru.se

Abstract

Background. Many patients undergoing anaesthesia and surgery experience postoperative complications. Our aim was to investigate whether a systematic follow-up smartphone-based assessment, using recovery assessment by phone points (RAPP) compared with standard care, had a positive effect on day surgery patients' postoperative recovery. We also investigated whether there were differences in women and men's recovery and recovery scores.
Methods. The study was a single-blind, multicentre randomized controlled trial. A total of 997 patients were randomly allocated to either RAPP or standard care. The Swedish web version of a quality of recovery (SwQoR) questionnaire was used to evaluate the patients' postoperative recovery, either on paper or using an application (RAPP) on postoperative days seven and 14.
Results. On postoperative day seven the RAPP group reported significantly better values in seven out of 24 items of the SwQoR: *sleeping difficulties; not having a general feeling of wellbeing; having difficulty feeling relaxed/comfortable;* and *dizziness; headache; pain in the surgical wound;* and a *swollen surgical wound* compared with the control group, implying a good postoperative recovery. Both men and women in the RAPP group reported significantly better values (and, hence good postoperative recovery) compared with the control group in the items *sleeping difficulties*; *not having a general feeling of wellbeing* and *pain in the surgical wound*.
Conclusions. Measurement of patient-reported outcomes using a smartphone-based application was associated with decreased discomfort from several postoperative symptoms. Systematic e-assessment can thereby increase patients' quality of recovery and identify key areas for improvement in perioperative care.
Clinical trial registration. NCT02492191.

Key words: mobile application; patient outcome assessment; postoperative complications; postoperative period

In the healthcare system today, more and more patients undergo day surgery.[1] Adverse events after anaesthesia and surgery affect patient satisfaction.[2–4] Most patients expect uneventful anaesthesia, but common early postoperative complications include pain, nausea and vomiting, headache, backache, sore throat, hoarseness, urinary retention, coldness, nerve injuries, and injuries to the lips and mouth.[3] These symptoms often arise after discharge from the hospital. As a result, many patients feel insecure, worried, and lonely owing to a lack of feedback and information regarding normality and appropriate expectations during the recovery process.[5]

Postoperative recovery should be evaluated using patient-centred outcome measures.[6] The 40-item Quality of Recovery (QoR-40) instrument assessing postoperative recovery[7] was

Editorial decision: July 3, 2017; **Accepted:** August 31, 2017

Editor's key points

- Patient web access via a smart phone can provide simple data collection in the postoperative period.
- This study identifies meaningful improvements in patient recovery when using a smartphone-based measurement of quality of recovery tool.
- Daily assessments by patients may be providing a positive feedback that enhances recovery.

previously tested in a population of Swedish patients who underwent day surgery, and was found to be valid and reliable for detecting changes in postoperative recovery.[8] This study, together with 17 other studies (including a total of 3459 patients), was included in a meta-analysis that showed that the QoR-40 has excellent validity, reliability, responsiveness, and clinical utility for use in a broad range of patient populations.[9] However, all of these studies relied on paper-based assessments of postoperative recovery. As an alternative to paper-based postoperative follow-up, smartphones should be ideal to use, as they are ubiquitous and owned by the large majority of people of all ages, and also starting to cross socio-economic and geographic boundaries.[10 11] The Swedish version of the QoR-40 has been further developed into a web version, the Swedish web version of Quality of Recovery (SwQoR) questionnaire and adapted to be used in a mobile application (app) called Recovery Assessment by Phone Points (RAPP). The SwQoR has been tested in a Swedish context and has been found to be valid and reliable.[12–14] There is a lack of systematic follow up after surgery and anaesthesia nationally and internationally.[15 16] RAPP assesses postoperative recovery and enables patients to initiate contact with the day surgery unit where the surgery was performed.[12 13] It has been described that using RAPP was helpful in the postoperative period and that the possibility to get in contact with the day surgery unit gave a sense of security, though many patients expressed difficulties getting in contact with health care.[12] To our knowledge there are no previous studies describing the effect of patients reporting their postoperative recovery. Our hypothesis was that RAPP would have a positive effect on postoperative recovery after day surgery.

The aim of this study was to investigate whether a systematic follow-up e-assessment using RAPP, compared with standard care, had a positive effect on day surgery patients' postoperative recovery. We also aimed to investigate whether there were differences in women and men's recovery scores.

Methods

Study design and participants

This study was carried out in accordance with the study protocol[1] and with the ethical standards of the Helsinki Declaration (6th revision) and was approved by the regional ethical review board in Uppsala (2015/262). The trial was registered with the US National Institutes of Health Clinical Trials Registry (NCT02492191).

This study was a multicentre, two-group, parallel, single-blinded randomized controlled trial conducted from October 2015 to July 2016 at four day surgery units in Sweden. The primary outcome for the overall study was cost-effectiveness when using the RAPP; this and other endpoints defined in the study protocol[1] will be reported elsewhere. This paper focuses on the postoperative recovery for patients undergoing day surgery.

Patients were informed about the study and asked to participate on the day of their surgery. The research nurse was responsible for participant inclusion at their day surgery unit and ensured that all participants who were eligible for inclusion in the study were asked to participate. Inclusion criteria were undergoing day surgery, >17 yr of age, access to a smartphone, and ability to understand spoken and written Swedish. Exclusion criteria were: visual or memory impairment, alcohol and/or drug abuse, or undergoing a surgical abortion. Written information about the study was sent out together with information about the planned surgery. Oral information was provided preoperatively on the day of surgery and oral and written consent was obtained from all participants.

Randomization and masking

Randomization was done by use of a computerized random numbers list generated by the Department of Clinical Epidemiology and Biostatistics at Örebro University (Örebro, Sweden), and implemented using sealed envelopes. Patients were randomly assigned in a 1:1 ratio, with permuted blocks of different sizes. Stratification was performed for each centre. This study was single-blinded, in that investigators performing the statistical analysis were blinded to group allocation.

Intervention

Patients were randomly allocated to the RAPP group (RAPP for follow-up after day surgery) or a control group. The controls were provided with standard information regarding postoperative recovery and told who to contact in the event of any concerns or complications (i.e. standard care). Standard care was considered as the routine care that was performed at each participating day surgery unit. This included information about who to call if concerns or questions. One unit performed a follow-up telephone call on postoperative day one to those patients that expressed a preference for this at discharge. Both groups were informed to contact a 24 h-telephone helpline if questions or concerns out of office h. Participants were advised to contact the local hospital's emergency department if needing acute care.

The RAPP application is an information technology solution that includes both a web administrator interface and an app assessing postoperative recovery using the SwQoR.[12–14] The SwQoR includes 24 negatively worded items scored on an 11 point numeric visual analogue scale from (0 "none of the time") to 10 ("all the time"). The SwQoR has a possible score range of 0 (excellent quality of postoperative recovery) to 240 (extremely poor quality of recovery). All items had to appear separately on the mobile phone screen and disappeared from the screen immediately after a response was given. Each item had to be answered in order to submit the daily assessment. The app was installed on the participants smartphones and functionalities of the RAPP were carefully explained, and clear instructions for using it given by the research nurse, including how to move from question to question, how to input a response, and how to use the navigation keys. The RAPP also contained a YES/NO question asking whether the patient wanted to be contacted by a nurse. If YES, a nurse at the day surgery unit where the surgery had been performed called the patient and offered further information and assistance. The number of contacts and the

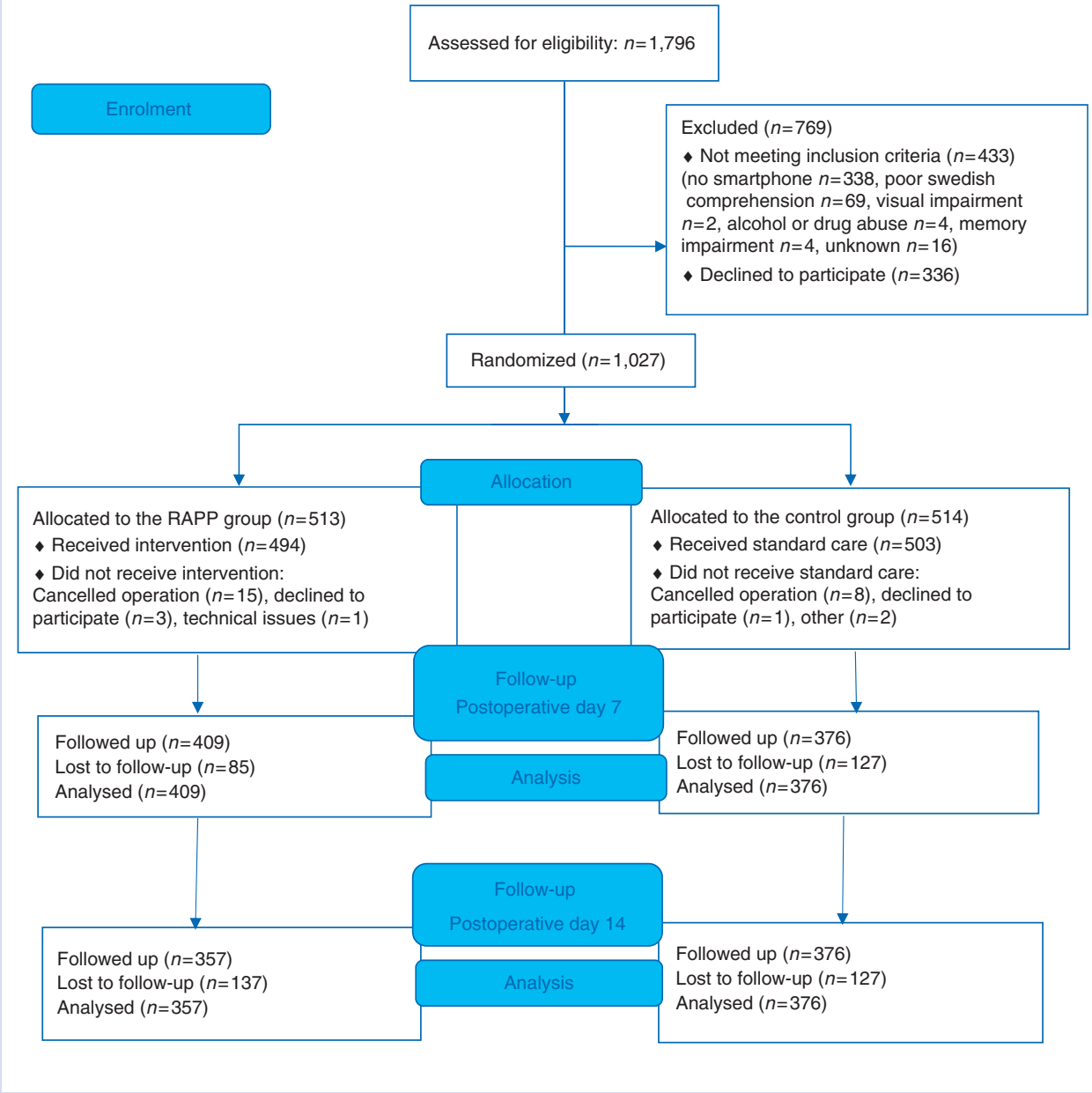

Fig 1 Flowchart of participants flow in the study.

reasons for contact requests were also documented and will be presented in another publication. The intervention started on postoperative day 1 and the RAPP was answered daily for 14 days. A daily reminder to answer the RAPP was sent via the app.

Outcomes and data collection

Postoperative recovery was measured using the SwQoR. Participants in the RAPP group used the app to answer questions, and those in the control group responded by writing on a conventional paper-based questionnaire on postoperative days seven and 14. The patients in the control group returned the questionnaires in a prepaid envelope. One reminder to return the SwQoR-questionnaire was sent out to the control group on postoperative day 14, by SMS text message or e-mail. Surgical and anaesthetic factors and patient characteristics data were collected from the patients' medical records.

Statistical analysis

A sample size of 1 000 participants was used, based on differences in quality-adjusted life-yr (QALY) weights between the groups (the primary outcome of the RCT).[1] Continuous data were tested for normality using the Shapiro-Wilks test. To compare differences between the intervention and the control group

Table 1 Patient characteristics, surgical and anaesthetic factors. No.(%) unless otherwise stated. ASA, American Society of Anaesthesiologist; ENT, Ear nose and throat surgery; §Missing data RAPP group *n*=94, Control group *n*=92. *Missing data RAPP group *n*=26, Control group *n*=23. ¤Missing data RAPP group *n*=25, Control group *n*=24. #Missing data RAPP group *n*=4, Control group *n*=8

	Intervention group *n*=494	Control group *n*=503
Patient sex M/F	220(45)/274(55)	235(47)/268(53)
Age Mean(SD)/Median (min-max)	45 (15)/46(18–81)	46 (15)/47(18–82)
ASA physical status§		
I	242 (49)	255 (51)
II	147(30)	148 (29)
III	11(2)	8 (2)
Type of anaesthesia*		
General anaesthesia	362(73)	369 (73)
	107(22)	111(22)
Regional or local anaesthesia		
Type of airway management¤		
Tracheal tube	77(16)	68(14)
Laryngeal mask	267(57)	279(58)
Mask	6(1)	3(0.6)
Spontaneous breathing	119(25)	129(27)
Type of surgery#		
Orthopaedics	160(32)	181(37)
General	126(26)	115(23)
Hand	116(24)	111(22)
ENT	52 (11)	49(10)
Gynaecology	26(5)	28(6)
Eye	5(1)	3(0.6)
Urology	3(0.6)	7(1.4)
Dental	2(0.4)	1(0.2)
Duration of surgery, min mean (SD)	40(29.6)	42(30.2)

with respect to gender, age, ASA physical status class, type of anaesthesia, type of airway management and type of surgery, we used absolute number, percent and mean (standard deviation (SD)). There were some unit non-responses in both groups. Unit non-response in the RAPP group for days seven and 14 was handled using last value carried forward (LVCF) if the participant had reported the recovery postoperative day six (*n*=64) or 13 (*n*=63) (i.e. the day before). Last value carried forward was performed under the assumption that the patient's score remained essentially constant from one day to another.[17] To detect differences between the two groups and gender differences, analyses were performed using χ^2 test, Mann-Whitney *U*-test or independent Student's *t*-test as appropriate. The magnitude of the significant symptoms in the SwQoR questionnaire was analysed using Cohens effect size (ES) (0.2–0.5=small effect, 0.5–0.8=moderate effect, >0.8=large effect) between the RAPP and the control group.[18] When analysing good or poor postoperative recovery, the assumption was that postoperative recovery improves over time, and the analysis was guided by the mean of the total SwQoR score on day seven for the whole group of patients (<31 *vs* ≥32–240) and the mean of the total score for postoperative day 14 (<21 *vs* ≥22–240). For statistical analyses, IBM SPSS statistics version 24 for Windows was used (IBM, Armonk, NY, US). A *P* value <0.01 was considered statistical significant in all analyses.

Results

In total 1797 patients were assessed for eligibility during the recruitment period. Figure 1 presents a flow chart of patient enrolment. Altogether 770 patients were excluded before randomization, for varied reasons; 434 patients did not meet the inclusion criteria; 336 declined to participate. The remaining 1027 patients were randomized to either the RAPP or the control group. Thirty patients were excluded from the analyses because of cancelled surgery, technical issues, declined participation or other reason, thus leaving 997 patients who were allocated to either the RAPP group (*n*=494) or the control group (*n*=503). On postoperative day seven 785 patients, and on day 14 733 patients answered the SwQoR questionnaire (Fig. 1). The two groups were comparable in respect of gender, age, ASA physical status class, type of anaesthesia and type of surgery (Table 1).

Quality of postoperative recovery

In general the RAPP group scored less discomfort from postoperative symptoms compared with the control group in eight of 24 SwQoR items on day seven. The RAPP group scored significantly lower values (*i.e.* indicating a good postoperative recovery) in the items; *sleeping difficulties*; *not having a general feeling of wellbeing*; *having a difficulty feeling relaxed/comfortable*; *dizziness*; *headache*; *sore mouth*; *pain in the surgical wound* and *swollen surgical wound* compared with the control group. The effect size of significant results showed small effects (0.10–0.35) (Table 2).

On postoperative day 14, the RAPP group still scored significantly lower values compared with the control group in the items, *sleeping difficulties*; *not having a general feeling of wellbeing*; *having a difficulty feeling relaxed/comfortable* and *pain in the surgical wound* with an ES of between 0.13–0.21 (Table 2).

On day seven, altogether 69% of the patients in the RAPP group reported a good postoperative recovery (i.e. a SwQoR–score<31) *vs* 57% in the control group (*P*=0.001). The corresponding proportions on day 14 (SwQoR<21) were 70% *vs* 64% (*P*=0.06). The global SwQoR score was significantly lower (*i.e.* indicating a better postoperative recovery) in the RAPP group compared with the control group on postoperative day seven (mean [SD] 28.23[29.97] *vs* 34.87[30.68], *P*<0.001) and postoperative day 14 (20.12[26.19] *vs* 21.90[22.40], *P*=0.002) (Table 2).

Postoperative recovery in women and men

There were no significant differences regarding patient characteristics baseline data between RAPP group and control group according to patient sex. The women in the RAPP group scored less discomfort in seven out of 24 SwQoR items on postoperative day seven compared with the women in the control group: *sleeping difficulties*; *not having a general feeling of wellbeing*; *having difficulty feeling relaxed/comfortable*; *dizziness*; *anxiety*; *headache* and *pain in the surgical wound*. On postoperative day 14 women in the RAPP group reported less discomfort in the items: *sleeping difficulties*; *having difficulties feeling relaxed/comfortable* and *pain in the surgical wound* (Table 3). Sixty-seven per cent of women in the RAPP group had a good postoperative recovery *vs* 54% of the women in the control group (*P*=0.008) on day seven: on

Table 2 Mean (SD) Swedish web version of quality of recovery (SwQoR) scores in recovery assessment by phone points (RAPP) and control groups on postoperative day seven and day 14. *Analysed with the Mann-Whitney *U*-test. Swedish quality of recovery scores: 0 "none of the time" and 10 "all of the time". Higher score indicates poorer postoperative recovery. †Effect size index. 0.2–0.5 small effect, 0.5–0.8 moderate effect, >0.8 large effect

Item	RAPP group Day 7	Control group Day 7	P-value*	Cohen effect size†	RAPP group Day 14	Control group Day 14	P-value[a]	Cohen effect size[b]
Trouble breathing	0.39(1.17)	0.47(1.49)	0.63		0.22(0.78)	0.24(1.10)	0.48	
Sleeping difficulties	1.54(2.56)	2.49(2.84)	<0.001	0.35	1.06(2.12)	1.54(2.35)	<0.001	0.21
Not having a general feeling of well-being	1.49(2.21)	2.27(2.64)	<0.001	0.32	1.11(2.01)	1.50(2.26)	0.007	0.18
Not feeling in control of my situation	1.14(2.07)	1.52(2.47)	0.074		0.85(1.84)	1.12(2.28)	0.11	
Having difficulty feeling relaxed/comfortable	1.55(2.30)	2.05(2.52)	0.001	0.20	1.09(2.08)	1.37(2.11)	0.008	0.13
Voice not sounding the same as usual	0.57(1.70)	0.63(1.84)	0.95		0.29(1.15)	0.39(1.52)	0.80	
Having difficulty taking care of my personal hygiene	1.78(2.49)	1.72(2.51)	0.29		1.54(2.46)	1.17(2.03)	0.032	
Having difficulty returning to work or usual home activities	4.14(3.55)	4.65(3.65)	0.080		3.06(3.38)	3.19(3.46)	0.77	
Nausea and/or vomiting	0.57(1.57)	0.87(2.12)	0.43		0.34(1.12)	0.29(1.19)	0.059	
Dizziness	0.60(1.55)	1.00(2.08)	0.006	0.21	0.43(1.31)	0.43(1.33)	0.81	
Depressed	1.10(1.95)	1.52(2.38)	0.050		0.78(1.74)	1.03(1.95)	0.032	
Anxiety	1.08(1.99)	1.48(2.36)	0.021		0.90(1.91)	0.97(1.83)	0.22	
Headache	0.86(1.88)	1.21(2.11)	0.005	0.17	0.67(1.65)	0.83(1.71)	0.033	
Muscle pain	1.37(2.16)	1.90(2.72)	0.058		1.20(2.07)	1.45(2.37)	0.31	
Sore throat	0.60(1.65)	0.60(1.62)	0.98		0.24(0.91)	0.29(0.97)	0.36	
Sore mouth	0.39(1.33)	0.26(1.14)	0.012	0.10	0.22(0.90)	0.15(0.80)	0.067	
Difficulties concentrating	1.13(2.02)	1.04(1.91)	0.37		0.74(1.66)	0.71(1.52)	0.79	
Trouble urinating	0.33(1.14)	0.45(1.47)	0.91		0.19(0.79)	0.22(1.0)	0.99	
Diarrhea	0.43(1.42)	0.52(1.57)	0.96		0.29(1.19)	0.34(1.17)	0.44	
Feeling constipated	0.64(1.70)	1.09(2.29)	0.024		0.41(1.40)	0.50(1.54)	0.39	
Fever	0.31(1.13)	0.32(1.21)	0.26		0.20(0.90)	0.20(0.98)	0.21	
Pain in the surgical wound	2.80(2.74)	3.69(2.92)	<0.001	0.31	1.79(2.46)	2.27(2.47)	<0.001	0.20
Reddened surgical wound	1.46(2.37)	1.61(2.45)	0.67		1.07(1.97)	1.14(1.94)	0.48	
Swollen surgical wound	1.93(2.64)	2.75(3.11)	0.001	0.28	1.37(2.23)	1.60(2.23)	0.025	
Global SwQoR score (0-240)	28.23(29.97)	34.87(30.68)	<0.001	0.21	20.12(26.19)	21.90(22.40)	0.002	0.07

Table 3 Mean (SD) Swedish web version quality of recovery (SwQoR) scores in women and men groups in recovery assessment by phone points (RAPP) and control groups at postoperative day seven and day 14. *Analysed with the Mann-Whitney *U*-test . SwQoR: 0 "none of the time" and 10 "all of the time". Higher score indicates poorer postoperative recovery. †Effect size index. 0.2–0.5 small effect, 0.5–0.8 moderate effect, >0.8 large effect

Item	Women RAPP- *vs* control group Day 7	P-value*/ Cohen effect size	Men RAPP *vs* control group Day 7	P-value*/ Cohen effect size	Women RAPP- *vs* control group Day 14	P-value*/ Cohen effect size	Men RAPP vs. control group Day 14	P-value*/ Cohen effect size
Trouble breathing	0.40(1.19)/ 0.49(1.41)	0.85	0.37(1.14)/ 0.44(1.59)	0.33	0.24(0.84)/ 0.25(1.10)	0.60	0.18(0.70)/ 0.23(1.10)	0.65
Sleeping difficulties	1.74(2.77)/ 2.77(2.91)	0.001/ 0.36	1.25(2.21)/ 2.13(2.70)	<0.001/ 0.36	1.25(2.39)/ 1.71(2.44)	0.005/ 0.19	0.79(1.62)/ 1.32(2.20)	0.021
Not having a general feeling of well-being	1.55(2.31)/ 2.34(2.72)	0.002/ 0.31	1.40(2.07)/ 2.17(2.54)	0.002/ 0.33	1.30(2.25)/ 1.66(2.47)	0.039	0.86(1.57)/ 1.29(1.95)	0.070
Not feeling in control of my situation	1.18(2.13)/ 1.58(2.44)	0.042	1.10(1.98)/ 1.45(2.52)	0.73	0.90(1.90)/ 1.32(2.48)	0.033	0.79(1.76)/ 0.87(1.99)	0.94
Having difficulty feeling relaxed/ comfortable	1.65(2.38)/ 2.31(2.74)	0.006/ 0.25	1.40(2.19)/ 1.70(2.16)	0.073	1.30(2.30)/ 1.66(2.38)	0.018	0.80(1.67)/ 0.98(1.62)	0.17
Voice not sounding the same as usual	0.64(1.87)/ 0.70(1.98)	0.94	0.48(1.43)/ 0.55(1.64)	0.99	0.33(1.32)/ 0.42(1.63)	0.78	0.23(0.85)/ 0.34(1.37)	0.95
Having difficulty taking care of my personal hygiene	1.79(2.52)/ 1.76(2.65)	0.28	1.77(2.46)/ 1.66(2.31)	0.70	1.58(2.46)/ 1.23(2.16)	0.059	1.48(2.47)/ 1.10(1.85)	0.29
Having difficulty returning to work or usual home activities	4.29(3.53)/ 4.64(3.61)	0.38	3.93(3.58)/ 4.65(3.70)	0.10	3.18(3.40)/ 3.15(3.69)	0.86	2.90(3.35)/ 3.26(3.60)	0.56
Nausea and/or vomiting	0.63(1.72)/ 1.25(2.52)	0.052	0.49(1.34)/ 0.37(1.32)	0.23	0.40(1.26)/ 0.43(1.52)	0.34	0.27(0.89)/ 0.10(0.40)	0.067
Dizziness	0.71(1.70)/ 1.39(2.42)	0.001/ 0.32	0.46(1.31)/ 0.49(1.36)	0.64	0.52(1.44)/ 0.57(1.59)	0.91	0.31(1.08)/ 0.24(0.85)	0.62
Depressed	1.26(2.17)/ 1.74(2.55)	0.062	0.87(1.59)/ 1.23(2.11)	0.42	0.91(1.91)/ 1.20(2.17)	0.045	0.61(1.44)/ 0.80(1.60)	0.32
Anxiety	1.14(2.07)/ 1.78(2.54)	0.004/ 0.27	0.98(1.88)/ 1.09(2.05)	0.89	1.10(2.17)/ 1.15(2.01)	0.21	0.63(1.43)/ 0.74(1.55)	0.66
Headache	0.91(1.96)/ 1.39(2.29)	0.011/ 0.22	0.78(1.77)/ 0.97(1.82)	0.18	0.79(1.79)/ 1.10(2.00)	0.015	0.51(1.44)/ 0.47(1.12)	0.69
Muscle pain	1.36(2.06)/ 1.97(2.92)	0.33	1.38(2.29)/ 1.80(2.44)	0.071	1.33(2.13)/ 1.69(2.56)	0.43	1.01(1.97)/ 1.14(2.07)	0.42
Sore throat	0.68(1.83)/ 0.66(1.79)	0.67	0.47(1.35)/ 0.52(1.37)	0.55	0.27(1.09)/ 0.31(1.02)	0.38	0.19(0.58)/ 0.25(0.89)	0.71
Sore mouth	0.37(1.32)/ 0.33(1.39)	0.19	0.41(1.34)/ 0.15(0.68)	0.020	0.23(1.02)/ 0.20(0.95)	0.46	0.20(0.71)/ 0.09(0.54)	0.045
Difficulties concentrating	1.27(2.18)/ 1.21(2.09)	0.63	0.93(1.76)/ 0.83(1.64)	0.43	0.88(1.87)/ 0.81(1.65)	0.76	0.54(1.29)/ 0.58(1.34)	0.95
Trouble urinating	0.29(1.06)/ 0.44(1.57)	0.77	0.38(1.25)/ 0.46(1.33)	0.67	0.16(0.72)/ 0.22(1.09)	0.84	0.22(0.89)/ 0.24(0.88)	0.88
Diarrhea	0.39(1.37)/ 0.62(1.73)	0.35	0.49(1.49)/ 0.39(1.33)	0.31	0.28(1.20)/ 0.40(1.35)	0.33	0.29(1.17)/ 0.25(0.88)	0.97
Feeling constipated	0.72(1.81)/	0.041	0.54(1.52)/	0.28	0.48(1.52)/	0.81	0.31(1.21)/	0.25

Continued

Table 3. (continued)

Item	Women RAPP- vs control group Day 7	P-value*/ Cohen effect size	Men RAPP vs control group Day 7	P-value*/ Cohen effect size	Women RAPP- vs control group Day 14	P-value*/ Cohen effect size	Men RAPP vs. control group Day 14	P-value*/ Cohen effect size
	1.24(2.51)		0.88(1.95)		0.62(1.83)		0.34(1.05)	
Fever	0.28(1.00)/ 0.34(1.30)	0.42	0.36(1.29)/ 0.29(1.10)	0.42	0.25(1.10)/ 0.22(1.10)	0.33	0.14(0.49)/ 0.14(0.79)	0.38
Pain in the surgical wound	2.81(2.77)/ 3.83(2.95)	<0.001/ 0.35	2.78(2.71)/ 3.49(2.89)	0.014/ 0.25	1.84(2.54)/ 2.40(2.53)	0.004/ 0.22	1.71(2.34)/ 2.09(2.38)	0.034
Reddened surgical wound	1.37(2.34)/ 1.53(2.43)	0.88	1.58(2.41)/ 1.72(2.48)	0.52	0.98(1.91)/ 1.02(1.92)	0.92	1.21(2.06)/ 1.28(1.96)	0.44
Swollen surgical wound	1.95(2.66)/ 2.55(3.10)	0.14	1.92(2.63)/ 2.99(3.12)	0.001/ 0.37	1.29(2.21)/ 1.48(2.15)	0.080	1.48(2.27)/ 1.75(2.32)	0.17
Global SwQoR score (0-240)	29.45(31.46)/ 37.84(33.57)	0.003/ 0.25	26.54(27.78)/ 31.35(26.52)	0.008/ 0.18	21.86(28.45)/ 23.74(23.99)	0.015	17.65(22.45)/ 19.64(20.14)	0.043

postoperative day 14 there were no significant differences between the groups. There were significant differences between men in the RAPP compared with the control group in the items; *sleeping difficulties* and *not having a general feeling of well-being*; *pain in the surgical wound* and *swollen surgical wound* on postoperative day seven. On postoperative day 14 there were no significant differences between the groups. There were no significant differences at any time for men between a good and a poor postoperative recovery.

The global SwQoR score was significantly lower (i.e. indicating a better postoperative recovery) in the RAPP compared with the control group both for women (mean [SD] 29.45 [31.46] *vs* 37.84[33.57], $P=0.003$) and for men (26.54[27.78] *vs* 31.35[26.52], $P=0.008$) on postoperative day seven. There were significant differences in the items *sleeping difficulties* and *pain in the surgical wound* on postoperative day 14 for women but there were no significant differences for men (Table 3).

Discussion

To our knowledge this is the first study reporting that daily measurement of postoperative recovery using an app can have a positive effect on recovery. In the postoperative period the patient may experience different postoperative complications.[3 19 20] The most common surgery-related complications after day surgery are haematoma/haemorrhage and infection.[21] Symptoms disturbing the patient most during the postoperative period include pain,[22 23] nausea and vomiting,[3 22 23] sore throat,[3] hoarseness[3] and insomnia.[22] In this study there were no significant differences in some of these, but patients in the RAPP group reported significantly less pain, swelling in the surgical wound, dizziness, headache, sore mouth and sleeping difficulties and a better general feeling of wellbeing and relaxation compared with the control group.

Patients admitted for day surgery are postoperatively monitored for only a few h before being discharged, at which point they must assume primary responsibility for monitoring their own recovery. Consequently, some patients feel insecure, worried and lonely because of lack of feedback and information regarding normality and appropriate expectations during the recovery process.[5 24] The reason behind the decreased symptoms and, hence, the increased quality of recovery in the present study may be explained by a greater awareness of the perception of quality of recovery if frequently assessing it. Furthermore, the content of the questions asked may in itself stimulate new thinking.[25] The degree to which the health care experience meets a patient's expectations is an important indicator of satisfaction.[26] As the patients in our study did not expect any monitoring of their symptoms after discharge, measuring them daily using an app may have been a positive experience in their postoperative period. However, the positive effect could also have been influenced by the last question in the RAPP, "Do you want to be contacted by a nurse?" The number of contacts will be presented elsewhere: however, results from an earlier study on the development of RAPP shows that the opportunity to get in touch with a nurse via the app was very much appreciated and made the participants feel secure. A positive attitude toward using the app was also reported here and furthermore, the patients reported feeling comfortable using the technology, and took a reasonable amount of time to answer the items in the app.[12] There is also a possibility of participant ascertainment bias, meaning that the control group might have felt less willing to report improvement in postoperative

recovery.[27] However if this was the case it indicates the willingness to use RAPP for follow-up after day surgery.

Several studies have reported that women are prone to a poor recovery compared with men.[28–30] According to Myles and colleagues[28] women experienced a near two-fold increased risk of many postoperative complications. The aim of the present study was not to compare women with men (this result will be presented elsewhere): instead, here we analysed women and men separately. Our results showed that women in the RAPP group reported significantly less symptoms in seven out of 24 items on day seven compared with women in the control group. Men in the RAPP group, on the other hand, reported significantly less symptoms in four out of 24 items.

To facilitate measuring postoperative recovery the SwQoR has been developed to be used as an app version (i.e. the RAPP).[12–14] According to the literature there is evidence of equivalence between paper-based patient-reported outcomes (PROs) and electronic patient-reported outcomes (ePRO).[31] Also, in a previous study we investigated and found equivalence between an app and a paper in day surgery patients.[12] Yet, in our development process we changed the positively worded items (n=7) to negatively worded items.[14] The use of both positively and negatively worded items is common in questionnaires. The original QoR-40[2 7–9] includes both positively and negatively worded item. It has been reported that questionnaires that combine positively and negatively worded items have lower levels of reliability and greater frequencies of inconsistent responses.[32] The primary reason for changing all items in the SwQoR questionnaire into negatively worded items was because it was something the patients asked for in a previous study.[12] Patients undergoing surgery are mostly used to scoring their postoperative pain using a visual analogue scale or numeric rating scale from 0 to 10. A moderate agreement (intercorrelation coefficient (ICC) 0.65) was found when testing the seven positively worded items against the negatively worded ones.[14]

In the present study we also present each item separately instead of merging items into the dimensions *Physical comfort*; *Physical independence*; *Emotional state* and *Pain* as recommended in the QoR-40.[2 7–9] The reason behind this is that we believe it is important to study each item separately when evaluating the effects of an intervention. To merge several symptoms into combined dimensions can dilute or blur the results and thus diminish the external validity. Our experience when conducting the study was also that clinicians and patients wants to consider each symptoms separately when evaluating the postoperative recovery.

We acknowledge that this study has several limitations. The SwQoR was not measured at baseline and the responsiveness could therefore not be analysed. Furthermore, approximately 30% of patients in this study did not return their SwQoR forms. Usually unit non-response is as a result of survey delivery or the person's decision not to participate in the study.[33] In this study all participants received a reminder to complete and send in the SwQoR. However unit non-response was handled with LVCF, in the RAPP group in those cases a response was reported on day six or 13. It was only possible to perform LVCF in the RAPP group as the control group only responded SwQoR day seven and 14. It has been suggested that missing data in a RCT should be handled with imputation in a modified intention to treat approach.[34] In this case when data from the day before was used in the analysis it would not have affected our results in favor of the intervention as postoperative recovery improves over time,[8] except from some few patients. On the other hand, we cannot ensure that the patients in the control group reported their recovery, on the paper based questionnaire, exactly on day seven and 14. Hence, there is perhaps more control over responses if using web-based follow-up questionnaires.

In conclusion measuring patient-reported outcome measures using an app can decrease the discomfort from several postoperative symptoms. Systematic e-assessment can thereby increase patients' quality of recovery and identify key areas for improvement in person-centred perioperative care. As day surgery expands and includes more extensive procedures in patients of increasing age and more serious co-existing diseases, increasing focus should be placed on follow-up to maintain quality and safety. Once we are able to systematically measure postoperative recovery, we can use these data to help identify complications and symptoms and determine the progress of recovery and thereby identify key areas for change.

Authors' contributions

Study design/planning: U.N., M.E., M.J.
Study conduct: U.N., K.D.
Data analysis: U.N., M.J., K.D.
Writing paper: U.N., M.J., K.D., M.E.
Revising paper: all authors

Acknowledgements

We would like to acknowledge, firstly, all patients included in this study and the research nurses, Maria Ståhlkrantz and Annelie Nilsson and Mikaela Breistrand and Anna Tonvik for their assistance in the data collection.

Declaration of interest

The author U.N. and the Örebro University Enterprise AB hold shares in RAPP-AB.

Funding

This study was founded by FORTE (the Swedish Research Council for Health Working Life and Health Care), (grant No. 2013–4765) and (the Swedish Research Council (Vetenskapsrådet), (grant No. 2015–02273).

References

1. Nilsson U, Jaensson M, Dahlberg K, *et al*. RAPP, a systematic e-assessment of postoperative recovery in patients undergoing day surgery: study protocol for a mixed-methods study design including a multicentre, twogroup, parallel, single-blind randomised controlled trial and qualitative interview studies. *Br Med J Open* 2016; **6**: e009901
2. Myles PS, Williams DL, Hendrata M, Anderson H, Weeks AM. Patient satisfaction after anaesthesia and surgery: results of a prospective survey of 10,811 patients. *Br J Anaesth* 2000; **84**: 6–10
3. Lehmann M, Monte K, Barach P, Kindler CH. Postoperative patient complaints: a prospective interview study of 12,276 patients. *J Clin Anesth* 2010; **22**: 13–21
4. Lemos P, Pinto A, Morais G, *et al*. Patient satisfaction following day surgery. *J Clin Anesth* 2009; **21**: 200–5
5. Berg K, Arestedt K, Kjellgren K. Postoperative recovery from the perspective of day surgery patients: a phenomenographic study. *Int J Nurs Stud* 2013; **50**: 1630–8

6. Myles PS. Perioperative outcomes: are we asking the right questions? *Can J Anaesth* 2016; **63**: 138–41
7. Myles PS, Weitkamp B, Jones K, Melick J, Hensen S. Validity and reliability of a postoperative quality of recovery score: the QoR-40. *Br J Anaesth* 2000; **84**: 11–5
8. Idvall E, Berg K, Unosson M, Brudin L, Nilsson U. Assessment of recovery after day surgery using a modified version of quality of recovery-40. *Acta Anaesth Scand* 2009; **53**: 673–7
9. Gornall BF, Myles PS, Smith CL, *et al*. Measurement of quality of recovery using the QoR-40: a quantitative systematic review. *Br J Anaesth* 2013; **111**: 161–9
10. Carroll JK, Moorhead A, Bond R, LeBlanc WG, Petrella RJ, Fiscella K. Who uses mobile phone health apps and does use matter? a secondary data analytics approach. *J Med Internet Res* 2017; **19**: e125
11. Miller DP Jr, Weaver KE, Case LD, *et al*. Usability of a novel mobile health iPad app by vulnerable populations. *JMIR MHealth UHealth* 2017; **5**: e43
12. Dahlberg K, Jaensson M, Eriksson M, Nilsson U. Evaluation of the Swedish Web-Version of Quality of Recovery (SwQoR): secondary step in the development of a mobile phone app to measure postoperative recovery. *JMIR Res Protoc* 2016; **5**: e192
13. Jaensson M, Dahlberg K, Eriksson M, Grönlund Å, Nilsson U. The development of the Recovery Assessments by Phone Points (RAPP): a mobile phone app for postoperative recovery monitoring and assessment. *JMIR MHealth UHealth* 2015; **3**: e86
14. Jaensson M, Nilsson U. Impact of changing positively worded items to negatively worded items in the Swedish web-version of the Quality of Recovery (SwQoR) questionnaire. *J Eval Clin Pract* 2017; **23**: 502–7
15. Segerdahl M, Warren-Stomberg M, Rawal N, Brattwall M, Jakobsson J. Clinical practice and routines for day surgery in Sweden: results from a nation-wide survey. *Acta Anaesth Scand* 2008; **52**: 117–24
16. Stomberg MW, Brattwall M, Jakobsson JG. Day surgery, variations in routines and practices a questionnaire survey. *Int J Surg* 2013; **11**: 178–82
17. Fayers PM, Machin D. *Missing Data. Quality of Life. The Assessment, Analysis and Reporting of Patient-Reported Outcomes*. Chichester, West Sussex, UK: John Wiley & Sons, Ltd., 2016; 393–427
18. Fayers PM, Machin D. *Quality of Life. The Assessment, Analysis and Reporting of Patient-Repored Outcomes*. Chichester, West Sussex, UK: John Wiley & Sons Ltd, 2016.
19. Myles PS. Clinically important difference in quality of recovery scores. *Anesth Analg* 2016; **122**: 13–4
20. Sveinsdottir H, Borgthorsdottir T, Asgeirsdottir M, Albertsdottir K, Asmundsdottir L. Recovery after same-day surgery in patients receiving general anesthesia: a cohort study using the quality of recovery-40 questionnaire. *J Perianesth Nurs* 2016; **31**: 475–84
21. Engbaek J, Bartholdy J, Hjortso NC. Return hospital visits and morbidity within 60 days after day surgery: a retrospective study of 18,736 day surgical procedures. *Acta Anaesth Scand* 2006; **50**: 911–9
22. Andion O, Canellas M, Banos JE. Physical well-being in postoperative period: a survey in patients, nurses and physicians. *J Clin Nurs* 2014; **23**: 1421–9
23. Macario A, Weinger M, Carney S, Kim A. Which clinical anesthesia outcomes are important to avoid? The perspective of patients. *Anesth Analg* 1999; **89**: 652–8
24. Svensson M, Nilsson U, Svantesson M. Patients' experience of mood while waiting for day surgery. *J Clin Nurs* 2016; **25**: 2600–8
25. McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J Clin Epidemiol* 2014; **67**: 267–77
26. Chow A, Mayer EK, Darzi AW, Athanasiou T. Patient-reported outcome measures: the importance of patient satisfaction in surgery. *Surgery* 2009; **146**: 435–43
27. Jadad AR, Enkin MW. *Randomized Controlled Trials. Questions, Answers and Musings*. India: Blackwell Publishing, 2007
28. Myles PS, Hunt JO, Moloney JT. Postoperative 'minor' complications. Comparison between men and women. *Anaesth* 1997; **52**: 300–6
29. Myles PS, McLeod AD, Hunt JO, Fletcher H. Sex differences in speed of emergence and quality of recovery after anaesthesia: cohort study. *Br Med J* 2001; **322**: 710–1
30. Buchanan FF, Myles PS, Cicuttini F. Effect of patient sex on general anaesthesia and recovery. *Br J Anaesth* 2011; **106**: 832–9
31. Coons SJ, Gwaltney CJ, Hays RD, *et al*. Recommendations on evidence needed to support measurement equivalence between electronic and paper-based patient-reported outcome (PRO) measures: ISPOR ePRO Good Research Practices Task Force report. *Value Health* 2009; **12**: 419–29
32. Solis SM. The dilemma of combining positive and negative items in scales. *Psicothema* 2015; **27**: 192–200
33. Phillips AW, Reddy S, Durning SJ. Improving response rates and evaluating nonresponse bias in surveys: AMEE Guide No. 102. *Med Teach* 2016; **38**: 217–28
34. Polit DF, Gillespie BM. Intention-to-treat in randomized controlled trials: recommendations for a total trial strategy. *Res Nurs Health* 2010; **33**: 355–68

Handling editor: Paul Myles