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Original Contribution

Effectiveness of a digital vs face-to-face preoperative assessment: A randomized, noninferiority clinical trial

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HIGHLIGHTS

- Digitally screened patients have the same postoperative recovery compared to face-to-face screened patients.
- Not seeing a physician in the preoperative phase does not increase preoperative anxiety.
- A digital preoperative screening can reduce loan costs by a third.
- A digital patient portal provides 24/7 access for patients to review preoperative information and instructions.

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ABSTRACT

Study objective: Digitalizing the preoperative assessment clinic can be a solution to keep up with the growing demand for surgery. It remains unclear if a digital preoperative assessment clinic is as safe, and effective in terms of patient health outcomes and experience compared to face-to-face consultations. This study aimed to compare quality of recovery and mental state in patients undergoing a digital preoperative assessment versus regular face-to-face consultations.
Design: This was a single centre, randomized (1:1), parallel, open-label, noninferiority trial.
Setting: The preoperative clinic and preoperative unit of an urban secondary care hospital.
Patients: All adult, Dutch speaking, ASA I-IV patients with access to an online computer who required surgery.
Interventions: Digital preoperative screening, consisting of an electronic screening questionnaire and web-based platform with personalized information and recommendations related to the procedure, or face-to-face screening, consisting of two 20-min in-hospital consultations.
Measurements: The primary endpoint was quality of recovery, measured 48 h after surgery. The analysis followed a per-protocol principle, and only patients who underwent the intended screening were included in the analysis. The noninferiority margin was set at −6. The trial was registered at ClinicalTrials.gov, NCT05535205, during the study on 09/08/2022, before analysing results.
Main results: Between March 1, 2021 and 30 august 2021, 480 patients were assessed for eligibility. 400 patients were randomly assigned to the digital group ($n = 200$) or face-to-face group ($n = 201$), of which respectively 117 and 124 patients were eventually included in the primary analysis. The mean quality of recovery score of patients undergoing digital screening (158) was non-inferior to that of patients undergoing face-to-face screening (155), with a mean difference of 3·2 points and a 97.5% lower confidence limit of −2.1 points. There were no adverse events.
Conclusions: A digital preoperative screening is not inferior to face-to-face consultations in patients undergoing predominantly low to moderate risk surgery. Given its potential to reduce physician workload, reallocate healthcare resources, and lower healthcare costs, a digital preoperative screening may be a better choice for preoperative assessments.

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1. Introduction

The preoperative assessment clinic (PAC) is essential to mitigate patient risk during surgery and support patient recovery. An effective PAC reduces postoperative length of hospital stay, lowers perioperative morbidity and mortality, and can decrease case delay and last-minute surgery cancellation. [1–7] To achieve this, the giving and gathering of relevant information over patient's health status and, from a patient perspective, the clear communication about the procedure, the potential risks and what this means for the individual patient, is key. [8] However, conducting PAC to a high standard is time-intensive and the growing demand for procedures, by a growing population of patients with advanced age, puts pressure on screening departments worldwide. [9] In the meantime, digital healthcare platforms are making transformative changes to conventional healthcare processes, which can be a solution for growing waiting lists and can provide many beneficial improvements for patients, caregivers, and society. [10]

Multiple studies investigated the efficiency of a (partly) digital PAC and found it can prioritize time of caregivers and safe costs. [9,11–17] The most recent study, by Milne-Ives et al. (2022), evaluated a digital screening platform for patients to complete questionnaires and review information, which reduced employee workload and costs by 38%. Of 1630 patients that completed the preoperative assessment, half did not require any further face-to-face follow-up, and it took physicians a median of 5.3 (IQR 3.2–12.9) minutes to review the preoperative assessments. However, it remains unclear if digital preoperative assessment methods are as effective and safe as face-to-face assessments in terms of patients' physical and mental perioperative health status and experience, using validated patient reported outcome measures. This information is important for caregivers, patients, and policymakers to decide which intervention benefits most, and for what price.

Therefore, this study aims to (1) demonstrate the noninferiority of a digital preoperative screening, in terms of postoperative quality of recovery, compared with a face-to-face preoperative screening in patients requiring surgery, and (2) demonstrate if there is a difference in preoperative anxiety, decisional conflict, patient satisfaction, postoperative admission days, morbidity, mortality, American Society of Anaesthesiologists (ASA) physical status score reliability, and costs.

2. Materials and methods

2.1. Study design

This was a randomized, parallel, noninferiority, open-label trial performed at 2 locations of a Dutch, urban, secondary care hospital. The trial protocol was approved by the Medical Research Ethics Committee in Utrecht and by the institutional research board of the hospital. The trial was performed in accordance with the Declaration of Helsinki and updated CONSORT 2010 guidelines for noninferiority and equivalence trials. The trial was registered at ClinicalTrials.gov (NCT0553520) during the study on 09/08/2022, before any data was analysed. The aims of this study were to (1) demonstrate the noninferiority of a digital preoperative screening, in terms of postoperative quality of recovery, compared with a face-to-face preoperative screening in patients requiring surgery, and (2) demonstrate if there is a difference in preoperative anxiety, decisional conflict, patient satisfaction, postoperative admission days, morbidity, mortality, ASA physical status score reliability, and costs.

2.2. Patients

Patients aged 18 years and older, admitted to the PAC department with a request to undergo surgery were evaluated for study enrolment. Patients referred for surgery from the following specialties in the hospital were included: general surgery (vascular, traumatic, gastrointestinal, oncological), gynecology, otolaryngology, neurosurgery, plastic surgery, orthopedics, and ophthalmology. The trial inclusion criteria were ASA physical status I to IV, fluent in Dutch, the availability of an online personal computer at home, and able to give informed consent. Exclusion criteria were pregnant women, and patients undergoing a non-standard pre-operative screening procedure that included breast- and gastrointestinal oncology and cardiac procedures. These patients are screened by a specialized nurse in our hospital and undergo a specific prehabilitation program, which is not yet implemented in the digital patient portal. All patients provided written informed consent for the trial.

2.3. Randomization and masking

Patients visiting the PAC were screened by the investigators (BTVH, DJT, RCMVR, LXVR) for eligibility and were subsequently informed on the aims and requirements of the study, after which written informed consent was obtained. Participants were randomly assigned (1:1) to either a digital preoperative screening or a face-to-face preoperative screening without blocks or stratification. A computer-generated randomization list (using R 4.2.1) was prepared by the principal investigator (BTVH) and incorporated within a web-based trial database, in which treatment allocation was only concealed after assigning the patient to the consecutive participant number. Quality of recovery and secondary PROMs were assessed by patients using paper-based questionnaires, masked from the investigators, and processed by the principal investigator (BTVH) after the interventions. Participants and investigators were not masked to group assignment. The analyses were done by a blinded researcher.

2.4. Procedures

Both interventions comprised a preoperative screening that extended from the time of randomization to the day of surgery. A protocol was used to standardize the extent of contact between patients and physicians. The aim was to ensure no systematic differences between interventions, beyond the intervention itself. Patients were informed on the intervention alternatives before random allocation.

The control group consisted of a face-to-face screening including two standard 20-min consecutive consultations with a nurse and an anaesthesiologist or physician assistant (PA). Information provided was not scripted since we aimed to compare the intervention with standard-of-care. The nurse obtained basic patient health information, provided information on the upcoming hospital admission, and gave advice in lifestyle procedures around the surgery. Subsequently, the physician assessed the patient's health status and based on co-morbidities, medication use, previous surgery, and lifestyle habits predicted the preoperative risks and assigned patients with an ASA physical status score. In accordance with patients' preferences the most optimal anaesthetic technique was chosen and informed consent, to proceed with surgery, was obtained. If required, additional diagnostics (e.g., blood test, electrocardiogram, x-ray), were ordered and scheduled the same day.

The intervention group comprised a digital screening in where patients provided health information through an electronic screening questionnaire and had access to a web-based portal to review information and recommendations related to their upcoming surgery. The screening questionnaire that is normally used by the nurse, consisting of 50 health related questions (e.g., previous procedures, illnesses, medication use, lifestyle habits), was digitalized and integrated with the digital patient portal. Patients could assess the electronic questionnaire directly after inclusion on a hospital computer or at home. Through the same web-based patient portal, patients had access to animated instructional videos. The videos informed patients on risks associated with the various anaesthetic procedures, how to prepare for admission (lifestyle advises, checklist of items to bring, and transport to the hospital) and anaesthesia (medication use and last meal), what to expect after surgery (symptoms, medication use, mobility), and what to arrange

for their aftercare. They were created, in collaboration with a third commercial party and not specifically for this research purpose, to fully cover the information normally provided by the nurse and physician with the additional advantage that the videos could be reassessed. Physicians screened the patient based on the electronic questionnaire and information in the medical record and subsequently assigned an ASA physical score. In case any diagnostic tests were required, these could usually be planned in combination with other in-hospital appointments or at the day of surgery. After the screening, a telephone appointment was scheduled with the patient solemnly to decide on the anaesthesia technique, based on patient preferences, and to obtain informed consent. Obtaining informed consent digitally was not permitted by the medical ethics committees when this study took place. Anaesthesiologists and PAs were thoroughly instructed not to provide more information or answer questions, and patients were well informed on this principle. Patients were instructed to complete the electronic screening questionnaire and assess the animated videos before the scheduled telephonic appointment with the physician. An automated message was instated on the day of allocation and one week later to notify patients of these requirements. When the requirement was not met, a new appointment was scheduled.

Patients who declined participation were screened by telephone, which was standard of care during the COVID-19 pandemic. This screening comprised two 20-min consecutive telephonic consultations with a nurse and physician.

Adverse events were defined as any clinically significant unfavourable change in the participants' physical or mental status, regardless of its relationship to the intervention. Mortality was classified as a serious adverse event.

Patient outcomes were assessed using paper questionnaires one day prior to surgery, and two days after surgery. Patient characteristics and baseline values were assessed verbally with the patient directly after inclusion at the preoperative department. For information on complications, mortality, surgery cancellation, and appointment cancellation the medical record was retrospectively assessed up until 30 days after surgery.

The study physicians were 14 anaesthesiologists and three PAs. PAs were specialized in the preoperative assessment, and they accounted for 60% of the screenings. Physicians were carefully instructed on the study aims and were trained in performing a digital screening in the two weeks prior to the start of the study.

2.5. Outcomes

The primary outcome was quality of recovery measured with the Quality of Recovery 40 (QoR-40) questionnaire and assessed at 48 h postoperative. The QoR-40 is a validated composite endpoint that is used in perioperative studies, and was incorporated in a recently developed set of core outcome measures for perioperative and anaesthetic Care (COMPAC), to guide outcome selection in perioperative clinical trials. [18–21] The questionnaire consists of 40 questions on a 5-point Likert scale that provides a global score and sub scores across five dimensions: patient support, comfort, emotions, physical independence, and pain. The highest achievable score, indicating maximum quality of recovery, is 200. The lowest score, indicating worst quality of recovery, is 40. The questions are related to the quality of recovery over the past 24 h. [22] Since the vast majority of participants was not hospitalized 48 h after surgery (97 of 117 vs 112 of 124 in the in-hospital group and digital group, respectively) the 'support by hospital staff' domain, consisting of 3 questions which should only be completed by patients when hospitalized, was omitted to prevent imbalances between groups. Scores on the modified version could range from 37 to 185 points. QOR-40 is translated and validated in Dutch. The QOR-40 has shown excellent test-retest reliability (intra-class $r = 0.92$, $p < 0.001$) and internal consistency (Cronbach's alpha = 0.93, $p < 0.001$) in adults. [23,24]

The secondary outcomes included preoperative anxiety, decisional conflict, patient satisfaction with information and the procedure, ASA physical status score reliability, postoperative admission days, 30-day complications (due to surgery or anaesthesia e.g.: bleeding, infection, readmission), 30-day mortality, PAC appointment cancellation, surgery cancellation, and labour costs.

Preoperative anxiety was measured by the State-Trait Anxiety Inventory (STAI) Y form, which is the most used questionnaire for measuring anxiety and has been translated in Dutch. The STAI shows good internal consistency in the original study ($\alpha = 0.86$ to 0.95). [25] The questionnaire consists of two separate, 20-item, five-point rating scales for measuring trait and stat anxiety. The score range lies between a minimum of 20 to a maximum of 80 points, the highest score indicating the highest level of anxiety.

Decisional conflict in deciding on type of anaesthesia was measured using the widely used Decisional Conflict Scale (DCS), which is validated in Dutch. The internal consistency of the DCS in Dutch cancer patients was found to be sufficient to good ($\alpha = 0.61$–0.83). [26] It measures a person's perception of their uncertainty in making a choice about health care options based on 5 dimensions: feeling uninformed, feeling uncertain, feeling unsupported, feeling unclear about values, and feeling ineffective in decision making. It is a 16-item scale, ranging from 0 (no decisional conflict) to 100 (highest decisional conflict). Decisional conflict was only assessed in cases where patients had >1 option for anaesthesia.

Patient satisfaction with the provided or available information and satisfaction with the preoperative screening in its entirety was measured on a NR-scale ranging from 1 (not satisfied) tot 10 (most satisfied).

Secondary patient reported outcome measures (PROMS) were assessed 1 day prior to surgery and other outcomes were assessed using the electronic hospital record. Baseline values were assessed for STAI, directly after inclusion, and QOR-40 on 1 day prior to surgery. Our outcomes covered all endpoints recommended by the COMPAC set. [21]

ASA physical status score reliability was defined as the level of agreement between the ASA physical status assigned by the physician in the PAC versus the ASA physical status assigned by the physician in the preoperative unit. The anaesthesiologist responsible for the preoperative unit received instructions to perform a physical reassessment of all participants scheduled for surgery on that day and assign an ASA physical status. Physicians were not blinded to the ASA physical status score assigned on the PAC, although they reported being unaware of the classification during reassessment due to the rapid turnover of patients in most cases.

Costs were calculated from an employee workload perspective. Labour costs represented the total expenditure incurred by the hospital for the employment of the nurses and physicians and were based on the Dutch Collective Labour Agreement (CAO) and the Labour Terms and Conditions Medical Specialists (AMS) for anaesthesiologists.

Patient characteristics included age, sex, smoking, body mass index (BMI), diabetes, use of blood thinners, ASA physical status score, health literacy, years of education, work status, marital status, history of anaesthesia, number of previous operations, type of anaesthetics to be performed, treating specialty, and procedure risk. Health literacy is the ability to gather, understand, and use health information to make health-related decisions. The Newest Vial Sign (NVS) health literacy test is based on a nutrition label of vanilla ice cream, with an overall score ranging from 0 to 6. As in the original NVS study, we separated the resulting NVS scores into inadequate (0–3) and adequate (4–6) health literacy. [27] The procedure risk was classified as low, moderate, or high (Supplemental material 3 – Procedures and risks).

2.6. Statistical analysis

This sample size calculation was based on noninferiority tests for our continuous primary outcome quality of recovery score (QoR-40) measured at 48 h after surgery. The noninferiority margin was set at −6 points, which was based on a study by Myles et al. who found a minimal

clinical important difference (MCID) of 6.3 for the QOR-40 questionnaire, which was subsequently rounded down. [28] Based on this study, we expected a QoR-40 score of 177 with a standard deviation of 16 on postoperative day 2 in the control group (face-to-face consultations). A total of 224 patients, 112 in each group, would yield a power of 80%, using a one-sided 97.5% confidence interval (CI), to establish whether digital screening was noninferior compared to a face-to-face screening. With an estimated lost to follow-up of 25%, a total of 299 patients (150 patients per group) needed to be enrolled.

Primary analysis was based on a per-protocol sample including all randomized patients, without exclusions and patients lost to follow-up (Fig. 1), who underwent the allocated intervention. All statistical analyses were performed according to the study protocol (see registered protocol on clinicaltrial.gov). For the primary analysis, a linear mixed model (LMM) was conducted with intervention, QoR-40 baseline, sex, and extent of surgery as fixed effects and treating specialty as random effect. Sex and extent of surgery have been reported as significant predictors for poor QoR-40 outcome and were therefor included in the model. [29] LMM analysis was done using R version 4.2.1 for Windows 11. Assumptions for LMM, including normality of residuals, were checked and met.

The primary outcome of QoR-40 was presented as the mean difference between study groups (digital screening – face-to-face screening) with the lower limit of the one-sided 97.5% CI, and was labelled noninferior when the noninferiority margin of −6 lied outside the lower limit of the one-sided 97.5% CI. CIs were calculated using linear regression analysis. Eleven patients in the study group did not complete the QOR-40 questionnaire or QOR-40 baseline and were excluded, leaving 241 patients (124 in the digital group versus 117 in the face-to-face group) included in the primary analysis. These patients either did not include the questionnaire in the envelope or left it blank. This likely happened because they returned the questionnaires before their surgery and forgot they had to complete the QOR-40 questionnaire 48 h postoperatively. Missing data were imputed using mean substitution. Comparison of repeated analyses for the primary outcome, using data in which missing data was imputed with extreme values (lowest score of 1 and highest score of 5), showed no relevant changes in the mean difference and 97.5% CI of the difference between groups (Supplemental material 1 – Sensitivity analysis). Therefore, we can safely conclude the results will not benefit from complex multiple imputations models.

The secondary outcomes including preoperative anxiety, decisional conflict, satisfaction, and postoperative admission days (assessed

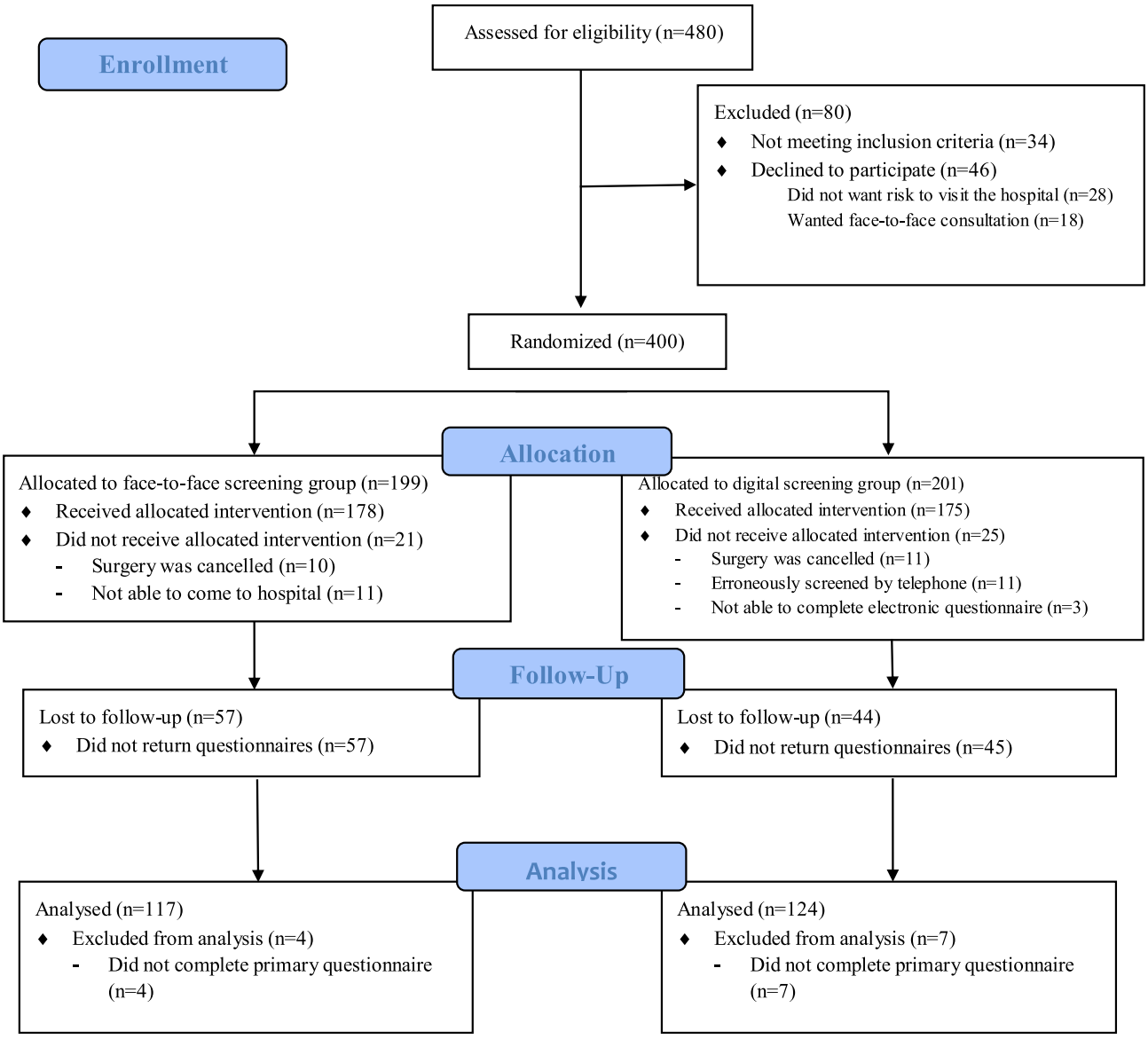

Fig. 1. Flow diagram.

retrospectively) were analysed using ANCOVA, controlling for QOR-40 baseline (fixed effect), and treating specialty (random effect) in LMM. Preoperative anxiety was also adjusted for its baseline values. Secondary analyses were based on a per-protocol sample. Assumptions including linearity, normality, homogeneity of residuals, and homogeneity of regression slopes were all met. Missing data were imputed using mean substitution. There is no consensus in literature about the MCIDs for STAI and DCS. Previous randomized controlled trials used MCIDs of 10 points for both questionnaires, requiring a total of 38 and 54 patients for the STAI and DCS respectively, using 80% power and an alpha of 0.05. [30–32] However, these MCID were chosen arbitrarily and seem liberate compared to proposed MCID calculation methods in literature. [28] Therefore, we employed different methods (0.3SD, 0.5SD, 5% instrument range) to determine the MCIDs and required sample sizes for both questionnaires (Supplemental material 2 – Minimal clinical important difference STAI and DCS).

ASA physical status score reliability for both interventions was calculated using quadratic weighted kappa scores (0 = random agreement between raters, 1 = complete agreement between raters).

Continuous data were presented in terms of the mean and the standard deviation (SD). Categorical data were presented which frequencies and percentages. Two-tailed *P* values <0.05 were considered statistically significant. There was no data monitoring committee established for this study.

2.7. Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

3. Results

From March 1, 2021 to 30 August 2021, a total of 480 patients referred for a PAC were screened by the investigators, and 400 were randomly assigned to either the face-to-face PAC ($n = 199$) or the digital PAC ($n = 201$; Fig. 1). Forty-six patients declined to participate because they refused did not want to visit the hospital ($n = 28$), or wanted a face-to-face consultation ($n = 18$), and 34 patients did not meet inclusion criteria. After randomization, 46 of 400 patients (12%) were excluded because their surgery was cancelled ($n = 21$), they were erroneously telephonically screened by the anaesthesiologist ($n = 11$), they were unable to visit to the hospital (n = 11), or they could not complete the electronic screening questionnaire ($n = 3$). After the intervention and surgery, 102 of 400 patients (26%) were lost to follow-up since they did not return the questionnaires, leaving 252 patients. Ninety-five percent (239 of 252) of patients completed the electronic questionnaire at home and all patients assessed the instructional videos at least once before the preoperative assessment. Baseline characteristics in the study sample were similar to the excluded group. Eleven patients did not fully complete the primary questionnaire, leaving 141 patients for the primary analysis (Table 1).

For the primary outcome, the mean between-group difference in quality of recovery was 3.2 with a 97.5% lower confidence limit of -2.1, establishing noninferiority. (Fig. 2; Table 2).

There was no statistically significant difference between the groups in preoperative anxiety (mean difference = 1.0; CI: −0.24 to 3.7; $p = 0.084$), decisional conflict (mean difference = −0.5; CI: −4.6 to 3.9; $p = 0.89$), and satisfaction with information (mean difference = −0.22; CI: −0.49 to 0.07; $p = 0.15$) and total screening process (mean difference = −0.24; CI: −0.58 to 0.07; $p = 0.12$), at 1 day before surgery. There was also no statistically significant difference in postoperative admission days (mean difference = −0.1; CI: −0.35 to 0.16; $p = 0.49$), complications (5% versus 3.8%; p = 0.89), cancelled PAC appointments, and surgery cancellations (7.4% versus 4.6%; $p = 0.35$), between the face-to-face and digital intervention respectively. There was no mortality. (Table 2).

Table 1
Baseline characteristics of the per protocol population.

Variables	n	Intervention		p-value
		Face-to-face ($n = 117$)	Digital ($n = 124$)	
Age, years	241	55 (42–68)	57 (37–72)	0.83
Female	241	55 (47%)	62 (50%)	0.74
ASA physical status score	241			0.49
1		31 (26%)	42 (34%)	
2		65 (56%)	67 (54%)	
3		19 (16%)	14 (11%)	
4		2 (2%)	1 (1%)	
Procedure risk	241			0.44
low		84 (72%)	84 (68%)	
moderate		32 (27%)	40 (32%)	
high		1 (1%)	0 (0%)	
Decided anaesthesia	241			0.54
General		92 (79%)	90 (73%)	
Regional		17 (15%)	24 (19%)	
Sedation		8 (7%)	10 (8%)	
Smoking	241	18 (15%)	19 (15%)	>0.99
Diabetes	241	8 (7%)	5 (4%)	0.50
BMI	241	26 (23−30)	25 (22–29)	0.086
Blood thinners	241	21 (18%)	24 (19%)	0.91
History of anaesthesia	240	95 (81%)	100 (81%)	>0.99
Number of procedures	236	2 (1–3)	2 (1–3)	0.69
Preoperative anxiety	240	33 (28–40)	34 (27–39)	>0.99
Health literacy	240			0.45
limited		35 (30%)	32 (26%)	
adequate		81 (70%)	92 (74%)	
Years of Education	237	17 (15–17)	17 (14–17)	0.98
Work status	240			0.36
working		76 (66%)	72 (58%)	
retired		34 (29%)	47 (38%)	
disabled		6 (5%)	5 (4%)	
Marital status	241			0.99
single		35 (30%)	37 (30%)	
partner		82 (70%)	87 (70%)	
Treating specialism	241			0.24
General surgery		58 (50%)	50 (40%)	
Otorhinolaryngology		16 (14%)	9 (7%)	
Plastic surgery		4 (3%)	12 (10%)	
Gynecology		2 (2%)	5 (4%)	
Orthopedics		19 (16%)	24 (19%)	
Urology		10 (9%)	9 (7%)	
Gastroenterology		2 (2%)	4 (3%)	
Neurosurgery		4 (3%)	6 (5%)	
Ophthalmology/Oral surgery		2 (2%)	5 (4%)	

Data are n (%), or median (IQR). BMI = body-mass index.

ASA physical status score reliability was 0.93 for the digital and 0.92 for the face-to-face group. For the digital and face-to-face group respectively, the physician in the preoperative unit assigned 5 (4%) and 2 (2%) patients to a higher, and 3 (3%) and 8 (7%) patients to a lower ASA physical status classification than the physician in the PAC (Table 3). All 7 patients who received a higher ASA physical status classification by the physician in the preoperative unit were assigned a classification one class higher.

Total labour costs were €3994 for the face-to-face group and €2779 for the digital group, which resulted in a 26% labour cost reduction. This could be mainly attributed to the fact that no nurse was required to collect basic health information, and inform patients on procedures around the upcoming surgery in the digital screening group. Thereby, consultation time for physicians in the digital screening was reduced to 15 min. Due to growing experience with the digital screening process, this could eventually be reduced to 10 min, which resulted in a labour cost reduction of 37% (€3994 versus €2500 for face-to-face and digital screening, respectively).

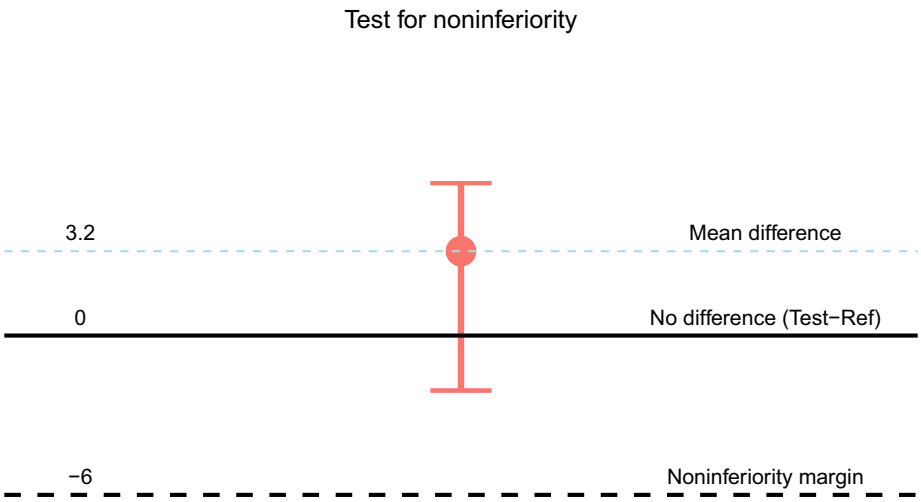

Fig. 2. The figure shows the result for the primary outcome. Test and Ref indicate quality of recovery (QOR-40) score in the digital and face-to-face group respectively. The red line indicates the absolute difference in quality of recovery (Test-Ref) with 95% confidence interval (CI) limits. The lower limit of the one-sided 97.5% CI for the difference is −2.1 and lays within the noninferiority margin of −6, concluding noninferiority for the digital group. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Primary and secondary outcomes results.

Group	Outcomes	Intervention		Absolute mean difference (digital - face-to-face; 95% CI)	P value
		Face-to-face	Digital		
Primary	QOR-40 score	155 (20)	158 (19)	3.2 (−2.1 to 5.7)	
Secondary	STAI score	37 (11)	38 (10)	1.0 (−0.24 to 3.7)	0.084
	DCS score	19 (14)	19 (13)	−0.5 (−4.6 to 3.9)	0.89
	Satisfaction with information	8.2 (1.1)	8.0 (1.2)	−0.22 (−0.49 to 0.07)	0.15
	Satisfaction with process	8.1 (1.1)	7.8 (1.5)	−0.24 (−0.58 to 0.07)	0.12
	Postoperative admission days	0.68 (1.2)	0.58 (0.94)	−0.10 (−0.35 to 0.16)	0.49
	PAC appointment cancelations	18 (14%)	15 (11%)		0.47
	Surgery cancelations	9 (7%)	6 (5%)		0.35
	Complications	6 (5%)	5 (4%)		0.89
	Mortality	0 (0%)	0 (0%)		

Data are n (%), or mean (SD). CI = Confidence interval. In the primary analysis, n = 117 (face-to-face) versus n = 124 (digital). In the Secondary analyses, $n = 118$ versus n = 130 for STAI; $n = 86$ versus 78 for DCS; $n = 119$ versus $n = 130$ for both satisfaction scores; $n = 126$ versus $n = 133$ for PAC cancelations, $n = 121$ versus 131 for the rest of the outcomes.

Table 3
ASA physical status score reliability per study group

		ASA score preoperative unit				
Group	ASA score PAC	1	2	3	4	Total
Digital	**1**	39	0	0	0	39
	2	2	59	4	0	65
	3	0	1	13	1	15
	Total	41	60	17	1	119
Face-to-face	**1**	37	1	0	0	38
	2	4	59	1	0	64
	3	0	4	16	0	20
	4	0	0	0	1	1
	Total	41	64	17	1	123

Quadratic weighted kappa scores were 0.93 and 0.92, for the digital and face-to-face group respectively. In the digital group, 5 patients (4%) received a higher ASA score on the preoperative unit versus 2 patients (2%) in the face-to-face group.

4. Discussion

Our results suggest that digital preoperative screening is noninferior to face-to-face preoperative screening in terms of patient quality of recovery. There was no difference in anxiety, decisional conflict, patient satisfaction, and postoperative admission days, and ASA physical status score reliability in the digital group was highly accurate, with similar high kappa values in the face-to-face group. Furthermore, labour costs were 26% lower in the digital preoperative screening group, and appointment and surgery cancelations were of lower frequency. This investigation adds to the emerging evidence of effective and efficient implementation methods of preoperative assessment clinics in patient requiring surgery in general.

There are two studies that directly compared a digital PAC with a face-to-face PAC. However, both studies focused primarily on efficiency parameters and did not include endpoints recommended by the COMPAC set. [21] Milves-ives et al. (2022) investigated the use of a digital platform were patients could complete an electronic assessment from which an ASA physical status score was derived based on an algorithm and were patients could find specific information about their procedure. They reported 85% of patients (317 out of 397) found the overall experience of their digital platform good or very good, against a potential reduction in service costs of 38% (7.2 WTE nurses and 3.6 WTE health care assistants versus 3.7 WTE nurses and 1.1 WTE assistants, for the face-to-face and digital PAC respectively). [9] Results on satisfaction are in line with satisfaction scores and cost reduction in our study. Blanco Vergas et al. (2015) retrospectively analysed 5112 elective surgical procedures in 2008 and 6867 procedures in 2010, respectively before and after the introduction of the online screening. They reported a drop of face-to-face consultations to 21%, and surgery cancellation before (2.3%) and after (1.8%) the introduction was in favour of the online screening but did not significantly differ, which is similar to our results. To our knowledge there are no studies present investigating the effectiveness of a digital PAC compared to standard of care using standardized patient-centred endpoints.

Multiple randomized controlled trials have used the QOR questionnaire to measure effects of preoperative interventions, including

different preoperative counselling methods and prehabilitation programs, and showed the QOR questionnaire to be a responsive measure in this setting (Supplemental material 4 - Systematic review). The QOR-40 questionnaire captures important domains of the patient-centered-recovery including the physiological, nociceptive, emotive, activities of daily, and satisfaction domains. In view of the relative absence of major complications the quality of recovery (QOR) is considered one of the principal endpoints in surgical care. [22,33–35] Since we used a modified version of the QOR-40 questionnaire, excluding the 'support by hospital staff' domain, following questionnaire guidelines, average QOR-40 scores are lower in this study. This should be taken into account when comparing results from other studies using the QOR questionnaire. As this procedure was conducted on all participants, the comparison of the groups will remain unaffected.

Although our study sample was too small to perform sub analyses for ASA physical status III-IV patients, our results suggest digital preoperative screening is safe for these patients. We found physicians were well capable of identifying surgical risks and assigning ASA physical status scores when screening patients digitally, even in more complex patients. We experienced that important comorbidities and diagnostic tests are well-documented, and that physicians seldomly required additional tests or presurgical optimization to approve for surgery. This observation was stressed during the recent years of the COVID-19 pandemic, where ASA physical status III-IV patients were screened by telephone and sometimes underwent invasive surgery without an increase in complications. Thereby, complication rates in ASA physical status III-IV patients were low and similar between the interventions. However, if a digital preoperative screening is as effective as a face-to-face screening in terms of perioperative physical and mental status, and patient satisfaction, remains unclear. High-risk patients often need to process more complex information and adhere to detailed and strict instructions to adequately prepare for surgery. Its effectiveness is largely determined by the quality and extent of the digital information that is provided, since it needs to be easy to access and understand, highly personalized to individual cases, and responsive enough to answer common patient questions. Nonetheless, we believe understandable, consistent, and 24/7 available digital information and instructions have the potential to be more effective than regular face-to-face communication, since communication errors and cognitive biases are common in face-to-face conversations and empathic opportunities are frequently missed. [36,37] Future trials will need to investigate which patient are less suitable for a digital PAC by investigating greater numbers of ASA physical status III-IV patients and higher risk procedures, using patient factor analyses. Factors that should be included are health literacy, digital literacy, socio-economic status and comorbidities. After this study, the digital PAC was implemented and covered 80% of the appointments, keeping 20% availability for in-hospital consultations for high-risk patients, patients without access to an online computer, and patients who prefer a face-to-face consultation.

The true cost-effectiveness of a digital PAC in a similar population is likely significantly higher than found in this study since cost were only viewed from a narrow hospital perspective. Reducing in-hospital consultations likely leads to lower societal costs since there will be less work absenteeism and lower costs related to transportation. Secondary advantages are less crowded and better accessible hospitals, and reduction of carbon dioxide emission.

This study has several strengths. Recruitment of ASA physical status I-IV surgical patients from all surgical specialties, corresponding frequency of socioeconomic patient characteristics (such as limited health literacy) with pooled estimates from a large meta-analysis, and the large number of participating physicians could contribute to the generalizability of the results. [38] Furthermore, this study had sufficient power to detect relevant differences in our secondary endpoints, and to our knowledge, this is the first noninferiority study testing the effectiveness of a digital PAC to a regular face-to-face PAC using validated PROMs. The use of various patient reported outcome measures adds important information on the effects of a digital PAC on patients' perioperative mental and physical status in a field with predominantly efficiency studies. The low amount of missing data is an additional strength of this study.

This study had some limitations. First, the frequency of ASA physical status III-IV patients in this study was lower than normally seen in our hospital. It is possible that more fragile or high-risk patients postponed their surgery due to the risks involved with the COVID-19 pandemic, or that these patients applied more to our exclusion criteria such as non-Dutch speaking and ability to use an online computer. This limits the generalisability and reduces the applicability of the findings to tertiary hospitals that provide care to patients with intricate comorbidities and procedures. Second, it was required by the ethics committee for physicians to obtain informed consent on anaesthesia technique by telephone after the digital screening. Although, physicians and patients were carefully instructed that no additional information exchange was to be taken place considering the study aims, it is possible that information was exchanged in a few cases. However, it is not likely that this has significantly affected our outcomes given the precautions taken. Third, this study was too small to compare morbidity between groups given the relative absence of serious complications. This issue is highlighted by previous studies. [29] Fourth, investigators were not masked to group assignment, however, the degree of bias resulting from this is likely neglectable for our primary and secondary PROMs since these were assessed by patients, without interference of investigators. Fifth, physicians were not blinded for the ASA physical status score assigned in the PAC, which could have affected ASA physical status score reliability. However, physicians claimed they were most of the time not aware of the classification during reassessment because of the high turnover of patients. Sixth, most patients were able to complete the digital assessment. These results may not be applicable to other patient populations with lower rates of digital competency.

In conclusion, a digital preoperative screening is not inferior to face-to-face consultations in patients undergoing predominantly low to moderate risk surgery. Given its potential to reduce physician workload, reallocate healthcare resources, and lower healthcare costs, a digital preoperative screening may be a better choice for preoperative assessments. Significant attention must be dedicated to the advancement and execution of a digital screening platform, as its effectiveness relies extensively on the quality of the digital content, the suitability of said content for each patient, and the accessibility and comprehensibility for individuals with limited (digital) health literacy. Future trials should focus on identifying patients who are less suitable for a digital screening by using greater sample sizes and patient factor analyses, including health literacy, digital literacy, socio-demographic variables, higher risk procedures, and patient comorbidities.

Data sharing

In the written informed consent before entering the trial, participants were informed that data from the study, which could not be used to identify them as individuals, could be shared with other researchers. The datasets are available if the material requested does not contain information that is classified as secret in accordance with the Public Access to Information and Secrecy Act. The assessment of the information in the material requested must be done at the time of the request and only if the information is secret can the request be denied. The decision over whether data are secret in cases where other researchers request data sharing includes judgment over whether individual people could be harmed by the data sharing. Requests to access the datasets should be directed to the principal investigator BTVH (bastiaanvanhoorn@gmail.com).

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CRediT authorship contribution statement

Bastiaan T. van Hoorn: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Daniel J. Tromp:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft. **Rosalie C.M. van Rees:** Data curation, Investigation, Writing – original draft. **Luke X. van Rossenberg:** Data curation, Investigation, Writing – original draft. **Hanna K. Cazemier:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing. **Mark van Heijl:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Supervision, Writing – review & editing. **Reinier C. Tromp Meesters:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Supervision, Writing – review & editing.

Declaration of Competing Interest

We declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclinane.2023.111192.

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