Introduction

Colonoscopy is the gold standard for diagnosis, surveillance and removal of precancerous lesions like adenoma in the colon, which reduces colorectal cancer mortality [1]. The importance herein is well advocated [2]. On the other hand, the prospect of undergoing colonoscopy and the intensive preparation might have a negative effect on patient comfort and anxiety [3].

Adequate bowel preparation is crucial, so it is paramount to optimally inform and instruct our patients prior to a colonoscopy [4]. Poorly prepared colons lead to a higher miss-rate of neoplasms, [5] more complications and increased need for repeat examinations with increased costs and cumulative discomfort for patients [6,7]. Therefore, to achieve adequate bowel cleanliness, patients have to adhere to prescribed use of laxative agents and dietary instructions [8]. Patient cleansing scores are influenced by ASA status, comorbidity, and treatment with gut motility modifying drugs. In our study, where these factors were unaffected by the intervention, we did not evaluate these further.

Patient education is obviously of key importance in achieving a well-prepared colon. Several educational tools are known...
to be effective in various degrees; e.g. informative leaflets, cartoons, video and dedicated counselling sessions by a nurse or a physician [3, 9–13]. Better education overall establishes higher quality of bowel preparation [14]. In the Netherlands the most common strategy is to provide nurse counseling prior to endoscopy.

In recent years, advances in internet technology provide us with novel, web-based education programs, enabling us to combine the previously mentioned modalities. Computer-assisted instruction (CAI), available on desktop and smartphone, helps to raise patient satisfaction about the information provided [15]. Proper implementation, however, is important [16].

The evidence base that supports use of CAI for bowel preparation is lacking. We hypothesise that CAI using video and 3D animations maximizes effectiveness of nurse counselling and therefore improves bowel cleanliness. Furthermore, CAI will positively influence the patient experience.

We conducted a pilot trial assessing the effectiveness of CAI for patient education prior to colonoscopy measuring bowel cleanliness and patient comfort and anxiety.

Patients and methods
We used a prospective, single center, endoscopist-blinded, controlled design to conduct our pilot study.

Patients
Consecutive patients older than 18 years referred for elective colonoscopy were included from March 2013 until November 2013 in a single, large-volume endoscopy center (over 4000 colonoscopies/year) in the upper Amsterdam Area in the Netherlands. Exclusion criteria were illiteracy in Dutch and significant audiovisual/mental handicaps. Patients were prescribed the same split-dose preparation regimen of picosulfate sodium and low-fiber dietary advice in the days preceding the colonoscopy.

Study design
After informed consent was obtained, patients were divided in 2 groups: the control group received nurse counselling and the intervention group received CAI. We administered 3 patient-questionnaires at 3 time points (See the flowchart in Fig. 1.)

In the first questionnaire, patients reported their baseline characteristics regarding age, gender, educational level, ethnicity, use of drugs, number of recent physician visits and experience in multimedia and Internet access. Patients rated comfort (“How do you feel after the received information?”) and anxiety (“How anxious are you”) on a 5-point Likert scale (T1). Subsequently the CAI group had contact with a trained endoscopy nurse for practical matters like bridging in anticoagulant therapy, insulin dosage calculation and scheduling of the colonoscopy. In addition, we also provided a unique hyperlink to the CAI with unlimited access. Next, patients were scheduled for colonoscopy, maximum 6 weeks after the counselling session.

After check-in at the endoscopy unit in the hour prior to colonoscopy, patients rated comfort and anxiety. Additionally patient knowledge and comprehension of the provided counsel-

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ling information were tested in a 10-question survey (T2). Within 2 hours post-colonoscopy, patient comfort was again scored on the 5-point Likert scale (T3).

During colonoscopy, the endoscopist assessed bowel cleanliness with the Boston Bowel Preparation Scale (BBPS): a cumulative score of 3 bowel segments, ranging from 0–1 “unsatisfactory”, 2–3 “poor”, 4–5 “fair”, 6–7 “good”, 8–9 “excellent” [17]. To detect subtle differences we applied the Ottawa Bowel Preparation Scale (OBPS). This scale is based on the combination of cumulative scores of 3 bowel segments (0 “excellent”, 1 “good”, 2 “fair”, 3 “poor”, 4 “inadequate”), with added points for the amount of residual fluid (0 “none”, 1 “moderate” and 2 “large”) [18].

Computer-assisted instruction
We designed interactive CAI, according to current best practices, such as good accessibility, plain language and a presentation that engaged the user [19]. We presented the information in a stepwise fashion. CAI consists of a web-based platform using video to mimic the patient journey with a voiceover sup-

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ported by photo’s, 3D animation and instructive texts (▶ Fig. 2. CAI is available in Dutch via https://trials.medify.eu/cai-colonoscopy). The video was presented in short clips, maximum of 45 seconds, to maintain patient focus. Patient interaction was ascertained by a mandatory mouse-click after each item in the CAI.

All informative elements, especially mandatory for informed consent for colonoscopy (risks, alternatives) were included.

Outcomes
The primary outcome was cleanliness of the colon during examination as assessed by the OBPS and the BBPS. The secondary outcomes were patient comfort with the received information, anxiety and knowledge and comprehension.

Statistical analyses
A sample size of 322 provides 80% power, with a 2-tailed α of 0.05, to detect an increase in the primary outcome measure (BBPS) from 6.0 in the control group to 6.5 in the experimental group, with a standard deviation of 1.6.

All analyses were performed using SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL, USA). We used descriptive statistics to describe baseline information including frequency count, percentage and mean ± standard deviation. Further analyses included the chi-square test, independent t-test and Mann-Whitney. P-values under 0.05 were regarded statistically significant.

Registration number
The trial was registered in ClinicalTrials.gov with number: NCT02656602

Ethical considerations
The study was approved by the institutional review board of the Medical Center Alkmaar.

Results
Patients
We included 385 patients, 197 in the nurse counselling group and 188 in the CAI group. Baseline characteristics regarding age, gender, educational level and ethnicity were equally distributed among both groups. Mean age was 57 years (range 18–83) in the nurse counselling group versus 59 years (range 18–89) in the CAI group. Educational levels were representative to the general Dutch population [20]. The majority of the participants were of Dutch ethnicity (87%) (▶ Table 1).

Both groups were also similar in the number of drugs used and recent physician visits. Use of email was comparably high, over 90% in both groups (90.9% versus 94.1% in the CAI group).

Overall scoring rate of data collection queries at the chosen time points was 99% at T1, 76.4% at T2 and 69.9% at T3. Patients who did not score at T1, T2 or T3 were not included in the time point analysis.

The bowel preparation regimen prescribed was picosulfate sodium (99%), in split dose. For clinical reasons, 2 patients received polyethylene glycol, sodium sulphate, sodium bicarbonate, sodium chloride, potassium chloride.

Primary outcome
Bowel cleanliness was equal in the 2 groups with mean total BBPS scores of 6.54 (±1.69) in the nurse counselling group and 6.42 (±1.62) in the CAI group. This is “good” according to the scale [17].

According to OBPS the nurse counselling group scored 6.07 (±2.53) and the CAI group 5.80 (±2.90). Here, the score is “good-fair” (▶ Table 2) [18]. Both scales were scored in 60.8% of all cases. Comparative analysis of the 39.2% of patients with missing scores showed no significant difference on age, gender or educational level.
Secondary outcomes

Comfort with the received information
Patient comfort scores directly after counselling (T1) were 4.54 ± 0.56 in the nurse counselling group and 4.17 ± 0.51 in the CAI group (p < 0.0001). Patient comfort scores prior to colonoscopy (T2) were significantly higher in the CAI group compared to the nurse counselling group (4.42 ± 0.68 vs 4.29 ± 0.62, P = 0.039). Patient comfort scores after colonoscopy (T3) were not different between groups (▶ Table 3).

Anxiety
We found no significant differences between groups in the 5-point Likert anxiety scores at T1 (total mean 3.04 ± 1.27) and T2 (total mean 2.84 ± 1.30) (▶ Table 3).

Knowledge and comprehension
The scores for the 10-question survey did not differ between groups (7.31 ± 1.11 vs 7.08 ± 1.17, P = 0.12) (▶ Table 3).

Discussion
The current study shows that CAI before colonoscopy results in well-prepared colons, comparable to face-to-face nurse counselling. We found that patients who were informed through CAI achieved higher grades of comfort. Interestingly, at baseline this rating was higher for the nurse counselling group, suggesting the influence of the human factor.

Current research on patient education in colonoscopy has been focused on use of leaflets, video, phone intervention and nurse or physician counselling sessions [3, 9–13]. In this era of information technology with Internet, social media and open access sources, computers are anchored in the seeking and gathering behavior by patients for medical instructions as it is fast, easy to use and ubiquitously accessible. The threat is that the information may be experienced as incomprehensible, insufficient and even incorrect. CAI, as provided by the endoscopy unit, has the potential to combine the upsides of the above tools without drawbacks such as passive learning [21].

CAI empowers the patient in place, pace and moment of learning, known to have impact on patients satisfaction [22]. In addition, reviewing and sharing online information with relatives is comfortably facilitated. In our trial, some patients viewed the CAI up to 6 or 7 times after being provided the secured unique patient hyperlink (data not shown). It is tempting to believe that this contributes to higher grades of comfort before colonoscopy using CAI.

### Table 1  Baseline Characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Nurse counseling</th>
<th>Computer Assisted Instruction</th>
<th>Nurse versus Computer Assisted Instruction (statistical test)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender (n, %)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>97 (49.2)</td>
<td>90 (47.9)</td>
<td>p = 0.789</td>
</tr>
<tr>
<td>Female</td>
<td>100 (50.8)</td>
<td>98 (52.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (mean, range)</strong></td>
<td>57 years, 18 – 83</td>
<td>59 years, 18 – 89</td>
<td>p = 0.09619 (t-test)</td>
</tr>
<tr>
<td><strong>Ethnicity (n, %)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Native Dutch</td>
<td>177 (89.8)</td>
<td>163 (86.7)</td>
<td>P = 0.384</td>
</tr>
<tr>
<td>Other</td>
<td>20 (10.2)</td>
<td>25 (13.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Educational level^1 (n, %)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>59 (29.9)</td>
<td>43 (22.9)</td>
<td>P = 0.131 (Mann-Whitney)</td>
</tr>
<tr>
<td>Middle</td>
<td>68 (34.5)</td>
<td>68 (36.2)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>70 (35.5)</td>
<td>77 (41.0)</td>
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</tbody>
</table>

^1 Highest completed educational level was split into 3 levels where “low” comprised no education through to lower secondary education, “middle” comprised upper secondary and middle vocational education, and “high” comprised higher vocational and tertiary education.

### Table 2  Primary outcome: Bowel Cleanliness during colonoscopy.

<table>
<thead>
<tr>
<th></th>
<th>Nurse counseling (n, % scoring rate)</th>
<th>Computer-assisted instruction (n, % scoring rate)</th>
<th>Nurse versus computer-assisted instruction (Mann-Whitney)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ottawa Bowel Preparation Scale (mean, SD)</td>
<td>6.07, ± 2.53 (n = 115, 58.4 %)</td>
<td>5.80, ± 2.90 (n = 87, 46.3 %)</td>
<td>P = 0.418</td>
</tr>
<tr>
<td>Boston Bowel Preparation Scale (mean, SD)</td>
<td>6.54, ± 1.69 (n = 129, 65.5 %)</td>
<td>6.42, ± 1.62 (n = 88, 46.8 %)</td>
<td>P = 0.576</td>
</tr>
</tbody>
</table>
Familiarity with use of computers, notably among elderly patients, could be of concern. In our cohort, 40% in the CAI group were older than 65 years. We did not find an age-dependent effect (data not shown). However, before drawing general conclusions from our results, we need to confirm this in larger studies.

Nurse counseling certainly provides personal contact and offers emotional support. Indeed, we observed higher comfort scores immediately after nurse counseling compared to CAI. On the other hand, limitations of this human factor in transferring information include distraction from the content, nuisances in the interpersonal domain and the non-uniformity by definition when different nurses or physicians are involved.

**Limitations**

A limitation of the current study is its non-randomized design. This was due to the unavailability of the CAI at the start of patient inclusion. However, this design did not affect the scoring by endoscopists as they were unaware of this information and therefore unaware of assignment over the groups while assessing the primary endpoint. The endoscopist scoring rate of 60% is most probably due to the limited administrative time in daily practice. Also, use of patient-reported questionnaires restricts medical data collection as compared to chart review. Therefore we cannot exclude the possibility of selection bias (such as previous experience with colonoscopy) in assessing secondary endpoints.

**Conclusion**

We conclude that implementing CAI leads to a properly cleaned colon at colonoscopy, with a positive impact on patient experience. Given the above results, this impact may be further augmented when combining the practical side of CAI with the option of a personalized nurse contact. Computer-aided representation of the patient journey through the medical landscape will require constant feedback and further research should include updates of the current CAI.

Use of a larger randomized controlled, multicenter trial design with these added elements might also show non-inferiority and cost-effectiveness of such an approach. Macroeconomic effects of less short-absence sick leave might also be interesting.

**Acknowledgements**

The authors would like to thank Tjeerd van der Ploeg for his statistical knowledge and support. This trial was funded by the Medical Centre of Alkmaar. Medify (software developer) had no role in the design and conduct of the study or in the writing and submission of the manuscript.

**Competing interests**

None

**References**


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