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Valori, RM; Damery, Sarah; Gavin, Daniel; Anderson, John; Donnelly, Mark; Williams, Graham; Swarbrick, Edwin

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A new composite measure of colonoscopy: the Performance Indicator of Colonic Intubation (PICI)

Dr Roland M. Valori, MB BS MD (Corresponding Author)
Consultant Gastroenterologist
Gloucestershire Hospitals NHS Foundation Trust
Gloucester
GL1 3NN
United Kingdom
roland.valori@nhs.net

Dr Sarah Damery PhD
Department of Primary Care Clinical Sciences
School of Health and Population Sciences
University of Birmingham
West Midlands
B15 2TT

Dr Daniel R. Gavin, MD, MB ChB
Consultant Gastroenterologist
Ipswich Hospital NHS Trust

Dr John T. Anderson, MB ChB MD
Consultant Gastroenterologist
Gloucestershire Hospitals NHS Foundation Trust
Cheltenham
GL53 7AN

Dr Mark T. Donnelly, MB ChB
Consultant Gastroenterologist
Sheffield Teaching Hospitals NHS Foundation Trust
Sheffield S5 7AU

Mr J. Graham Williams, MCh, FRCS
Consultant Surgeon
The Royal Wolverhampton Hospitals NHS Foundation Trust
Wolverhampton
WV10 0QP

Dr Edwin T. Swarbrick, MD
Consultant Gastroenterologist (retired)
The Royal Wolverhampton Hospitals NHS Foundation Trust
Wolverhampton
WV10 0QP

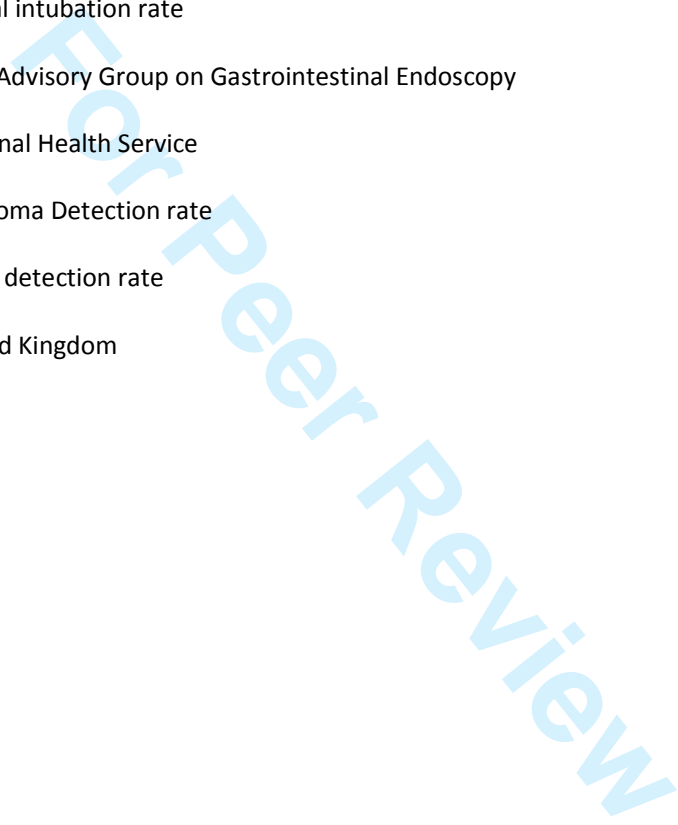
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Keywords:

Colonoscopy, Audit, Colorectal Cancer, Adenoma Detection rate, Caecal Intubation Rate, Accreditation, Polyp, Gastrointestinal Endoscopy, Performance Indicator

Abbreviations:

- PICI Performance Indicator of Colonic Intubation
- BCSP National Bowel Cancer Screening Program
- CIR Caecal intubation rate
- JAG Joint Advisory Group on Gastrointestinal Endoscopy
- NHS National Health Service
- ADR Adenoma Detection rate
- PDR Polyp detection rate
- UK United Kingdom



Background

Caecal intubation rate (CIR) is an established performance indicator of colonoscopy. Caecal intubation with acceptable tolerance is only achieved in some patients with more sedation. This study proposes a composite Performance Indicator of Colonic Intubation (PICI) combining CIR, comfort and sedation.

Methods

Data from 20085 colonoscopies reported in the 2011 UK national audit were analysed. PICI was defined as percentage of procedures achieving caecal intubation with median dose (2mgs) of midazolam or less, and nurse-assessed comfort score of 1-3/5. Multivariate logistic regression analysis evaluated possible associations between patient, unit, colonoscopist and diagnostic factors and PICI.

Results

PICI was achieved in 54.1% of procedures. PICI identified factors affecting performance more frequently than single measures such as CIR and polyp detection, or CIR + comfort alone. Older age, male sex, adequate bowel preparation and FOBT screen-positive as indication were associated with a higher PICI. Unit accreditation, the presence of magnetic imagers in the unit, greater annual volume, fewer years' experience and higher training/trainer status were associated with higher PICI rates. Procedures in which PICI was achieved were associated with significantly higher polyp detection rates than when PICI was not achieved.

Conclusions

PICI provides a simpler picture of performance of colonoscopic intubation than separate measures of CIR, comfort and sedation. It is associated with more factors that are amenable to change that might improve performance and with higher likelihood of polyp detection. It is proposed that PICI becomes the key performance indicator for intubation of the colon in colonoscopy quality improvement initiatives.

Study highlights**What is current knowledge?**

- There are three components of colonoscopy: safe and comfortable intubation; detection of pathology; and therapy
- Caecal intubation rate (CIR) is the current gold standard performance measure for intubation but a satisfactory CIR does not indicate whether intubation is safe or comfortable
- Sedation is usually required to achieve comfortable and complete colonic intubation and in many jurisdictions propofol has become a popular sedative agent
- Sedation for colonoscopy affects patient satisfaction, safety and costs

What is new here?

- A composite measure of colonic intubation (PICI) provides a broader and more discriminating picture of performance of colonic intubation than CIR alone
- PICI is better able to discern differences in performance in relation to colonoscopists, equipment and units than either CIR alone or polyp detection rates
- Unit accreditation (JAG) is associated with higher PICI
- PICI is associated with higher polyp detection rate

Introduction

Colonoscopy is the gold standard investigation of the colon for patients with symptoms and in many countries it is used for colorectal cancer screening. The quality of colonoscopy is important because poor quality colonoscopy is associated with more frequent adverse outcomes such as missed cancers [1,2] and complications. To monitor and improve performance surrogate performance indicators for colonoscopy are necessary as adverse outcomes are infrequent and difficult to capture reliably.

There are three components to colonoscopy: safe and comfortable intubation to the caecum; identification of polyps and other pathology; and safe and complete removal of polyps. Caecal intubation rate (CIR) is the traditional performance measure of caecal intubation, but it fails to take account of other variables that might reflect safety and experience, such as patient comfort and sedation.

A desire to achieve a high CIR in combination with sub-optimal technique can result in pushing harder to reach the caecum, making the procedure more uncomfortable, and possibly less safe, as colonoscopists push harder to reach the caecum. The increasing popularity of propofol suggests that patient tolerance of colonoscopy is an important barrier to widespread patient acceptance of conscious sedation for colonoscopy. However, propofol increases costs [3] and while some of these will be offset by faster colonoscopy (the colonoscopist is not constrained by patient pain) and quicker recovery (patients spend less time recovering than from benzodiazepine sedation), propofol sedation will remain unaffordable in countries where an anaesthetist is required to administer it.

In response to concerns about the impact on safety, comfort and sedation of using an unadjusted caecal intubation rate as a key performance indicator, the UK Joint Advisory Group on Gastrointestinal Endoscopy (JAG), has required all endoscopy units in the UK to monitor safety, sedation and patient comfort for all colonoscopies [4]. This study proposes a new

1 measure of colonic intubation, termed Performance Indicator of Colonic Intubation (PICI),
2
3 which combines three key parameters of colonic intubation: CIR; sedation; and patient
4
5 comfort. The data from a national audit of colonoscopy [5] performed in the UK in 2011 were
6
7 used to develop an initial standard and to test the utility of this measure to assess
8
9 performance. Finally, data from a single hospital endoscopy service were analysed to explore
10
11 how the PICI might be used in practice and to recommend potential performance targets.
12
13
14

15 **Methods**

16
17
18 The methodology and headline results of the 2011 UK national colonoscopy audit were
19
20 published in 2013 [5]. All National Health Service units performing >100 colonoscopies per
21
22 year agreed to participate. All colonoscopists in these units and all adult colonoscopies
23
24 performed during a two-week period in March 2011 were recorded on a web-based database.
25
26 Patient and case mix variables (age, gender, inpatient/outpatient procedure, primary
27
28 indication for colonoscopy and quality of bowel preparation), endoscopy unit factors
29
30 (accreditation status, presence of imaging facilities) and colonoscopist variables (experience
31
32 and training attainment) were captured. The 'presence/absence of a trainer' was a marker of
33
34 training occurring: if a trainer was present, then a trainee did all or part of that procedure. The
35
36 'trainee/independent' status indicated whether the person doing the procedure was still in a
37
38 training role or not.
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43
44 Accreditation, administered by the JAG, occurring on a five-year cycle, involves a peer review
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46 process assessing against a predetermined set of standards [6].
47
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49
50 Colonoscopy performance indicators included CIR, sedation, polyp detection and nurse-
51
52 assessed patient comfort using the Gloucester comfort scale [7]. The vast majority of patients
53
54 received a combination of an opiate and midazolam [5]. It is common practice in the UK and
55
56 many other countries for the patient to receive an opiate followed by midazolam at the outset
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1 of colonoscopy and if more medication is required midazolam is usually given in preference to
2 more opiate, even though midazolam does not have inherent analgesic properties.
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7 In the absence (at the time) of a validated comfort score for colonoscopy, the Gloucester
8 comfort scale was selected because it was in common use throughout the UK in 2011 and
9 because it correlates well with a simple measure of patient experience [7]. The scale has five
10 levels and assesses three components of discomfort: severity, frequency and impact on the
11 patient (distress):
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|----|-------------------------------|--|
| 17 | 1. <i>No discomfort</i> | Talking and comfortable throughout |
| 18 | 2. <i>Minimal discomfort</i> | 1 or 2 episodes of mild discomfort with no distress |
| 19 | 3. <i>Mild discomfort</i> | More than 2 episodes of discomfort without distress |
| 20 | 4. <i>Moderate discomfort</i> | Significant discomfort experienced several times with some |
| 21 | | distress |
| 22 | 5. <i>Severe discomfort</i> | Frequent discomfort with significant distress |
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33 The principal diagnosis was noted. The data were validated for completeness and accuracy [5].
34

35 *Statistical analysis*

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39 Achievement of PICI was defined as the proportion of all of the procedures of the audit that
40 achieved caecal intubation AND less than or equal to the median dose of midazolam (2mg)
41 AND a nurse-assessed comfort score of 1-3 ('comfortable' to 'mild discomfort'). PICI is a binary
42 indicator. Procedures in which PICI was not achieved are those in which one or more of the
43 three components of the indicator were not met. Thus:
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$$50 \text{ PICI\%} = \frac{\text{procedures with caecal intubation, AND comfort score 1-3, AND } \leq 2\text{mg midazolam}}{\text{all procedures}}$$

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PICI was compared to three further indicators of colonoscopy performance: CIR alone; CIR + comfort score 1-3; and polyp detection rate (PDR >1). In all analyses, CIR was adjusted for examinations not completed due to obstructing lesions.

As all predictor variables were categorical, analysis was based on a comparison of the characteristics of procedures in which the PICI was achieved vs. those in which it was not achieved. Multivariate binary logistic regression assessed patient, unit and colonoscopist variables in order to derive Odds Ratios (OR) and 95% confidence intervals (CI) for those that were independently associated with PICI after controlling for the effects of all other model variables. Regression analysis used the forward entry procedure, in which all variables were retained in the model regardless of statistical significance or individual contribution to the model. All OR and CI cited in the analysis are adjusted estimates from multiple logistic regression. To correct for multiple comparisons, a pragmatic reduction in the p value considered to indicate statistical significance was adopted (alpha 0.01).

Sensitivity of PICI as a performance indicator

Sensitivity in this context refers to whether PICI is more likely to find differences in performance for the variables captured in the study compared to the other three indicators (CIR, CIR + comfort and PDR>1). The data comprise four variables related to the patient (age, sex, procedure type, indication) and ten variables related to the unit or the colonoscopist (bowel preparation, country, accreditation, +/- imager, consultant status, professional group, colonoscopy and training experience, and whether training was occurring). Sub-group analysis was carried out for the variables most likely to be modifiable by change in practice (i.e. ten unit and colonoscopist variables comprising 25 sub-groups).

Relationship of PICI to polyp detection

1 This analysis looks at, on a case-by-case basis, whether PCl was achieved and whether a
2
3 polyp(s) was found and expresses the relationship in terms of an odds ratio – the relative
4
5 likelihood of finding polyps if PCl was achieved. There are three analyses: one for one or
6
7 more polyps and the second for 2 (the median) or more polyps and the third for cancer. All
8
9 analyses were adjusted for other variables that might independently be associated with PCl,
10
11 PDR and cancer.
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16 Statistical analysis was undertaken using SPSS version 21 (Armonk NY: IBM Corp).
17

18 *Single site composite caecal intubation rate*

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22 Colonoscopy performance data across four sites in Gloucestershire (population 550,000) is
23
24 collected on a single sequel-based reporting system [7], which contains two data fields (extent
25
26 of procedure and midazolam dose) required to create the PCl. Data are entered immediately
27
28 following procedures and both fields must be completed before a report can be generated.
29

30 Nurse-assessed comfort is recorded separately on the hospital patient administration system.
31

32
33 Data from the two databases are combined into a single database [7], which is updated every
34
35 night to produce real-time performance outputs for colonoscopists, which included PCl from
36
37 January 2014.
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41 Data are presented on all colonoscopies occurring between 1st January and 31st December
42
43 2013 inclusive. In order to provide an accurate reflection of the relationship of volumes to
44
45 PCl, only data from colonoscopists performing colonoscopy for the entire one year period are
46
47 included in the analysis.
48

49 **Results**

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53 Performance data were captured from 20,085 colonoscopies during the two-week audit,
54
55 representing 94.1% of all NHS procedures performed during this time [5].
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1 The criteria for achieving PICI were met in 54.1% of procedures (n=10,865) (Figure 1).
2
3
4 Procedures undertaken with older patients; males; and those where quality of bowel
5
6 preparation was 'adequate' or 'excellent' were significantly associated with PICI achievement
7
8 (comparison of proportions tests all significant to the $p < 0.0001$ level, supplementary Table 1).
9
10 For all unit and endoscopist variables (with the exception of independent/trainee status of the
11
12 endoscopist, and presence/absence of a trainer during the procedure), there was a statistically
13
14 significant difference in the proportion of procedures that achieved PICI (supplementary Table
15
16 2). 60% of procedures undertaken in JAG accredited endoscopy units achieved PICI, compared
17
18 to only 45.4% of procedures undertaken in non-accredited units. Procedures undertaken in
19
20 units with two or more imagers achieved PICI in 57.9% of cases. 62.3% of procedures
21
22 undertaken by practitioners with course faculty status achieved PICI.
23
24

25 26 27 *Multivariate modelling of variables associated with achieving PICI*

28
29
30 Table 1 outlines the Odds Ratio (OR), 95% Confidence Intervals (CI) and p values for all
31
32 variables in a multivariate model. Odds ratios indicate the likelihood that a given sub group
33
34 will be associated with achievement of PICI in comparison to the relevant 'reference' group.
35
36

37
38 All patient and case mix sub groups were associated with a statistically significant likelihood of
39
40 achieving PICI with the exception of procedure type. PICI was significantly more likely to be
41
42 achieved in procedures undertaken with older patients, males, and those undertaken due to
43
44 FOBT positivity. For the other variables, adequate or excellent bowel preparation, country, unit
45
46 JAG accreditation, having one or more imagers in the unit, procedures carried out by surgeons
47
48 or specialist practitioners, fewer years' experience, greater annual volume and course
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50 participation (including course faculty status) were associated with a significantly higher
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52 likelihood of achieving PICI. There were some important negative findings. There was no
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54 statistical difference when independent practitioners were compared to independent trainees.
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1 Likewise trainer presence, indicating that training was occurring did not show a significant
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3 difference.
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7 *Multivariate modelling of variables associated with achieving the CIR + comfort indicator*
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9

10 Table 2 outlines the multivariate modelling for CIR + comfort level 1-3, excluding the influence
11
12 of sedation. 86.7% of procedures (n=17417) met the criteria for the CIR + comfort indicator.
13

14 The direction of the association compared to PICI was reversed for two sub groups:
15
16 procedures undertaken in Wales were significantly more likely to achieve PICI than those
17
18 undertaken in England (OR 1.52, 95% CI: 1.27 to 1.81). In contrast, procedures undertaken in
19
20 Wales were significantly *less* likely to achieve the indicator based on CIR + comfort score 1-3
21
22 than those undertaken in England (OR 0.70, 95% CI: 0.56 to 0.88). Similarly, compared to
23
24 physicians, surgeons were significantly *more* likely to achieve PICI, but significantly *less* likely
25
26 to achieve the CIR + comfort indicator.
27
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31 *Comparative multivariate modelling of four colonoscopy performance indicators*
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33

34 Table 3 compares multivariate analyses for four different performance indicators (PICI, CIR +
35
36 comfort, CIR alone and PDR>1). 17 out of 25 sub-groups of the unit/training/colonoscopist
37
38 variables showed statistically significant OR for the likelihood of achieving PICI. Eight out of 25
39
40 categories were statistically significant predictors of CIR alone, compared to eight for CIR +
41
42 comfort level 1-3, and four for PDR >1. Thus PICI is more sensitive to impact on performance in
43
44 relation to the sub groups of unit/training/colonoscopist variables than the other three
45
46 indicators assessed.
47
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51 *Association between PICI and polyp/cancer detection*
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53

54 Achieving PICI was associated with a significantly higher likelihood of detecting one or more
55
56 polyps, compared to procedures that did not achieve PICI (OR: 1.44, 95% CI: 1.35 to 1.53). The
57
58 likelihood of detecting two or more polyps was also significantly higher when PICI was
59
60

1 achieved (OR: 1.45, 95% CI: 1.34 to 1.57). Achieving PICI was associated with an increased
2
3 likelihood of detecting cancer, although this was not statistically significant (OR: 1.14, 95% CI:
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5 0.98 to 1.32).
6
7

8 9 *Single site data*

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11
12 6236 colonoscopies were performed across four endoscopy sites in Gloucestershire during
13
14 2013. After removing procedures performed by locums or recent appointees (n=990), there
15
16 were 5246 colonoscopies, performed by 19 colonoscopists, for analysis. Annual procedure
17
18 volumes for each colonoscopist ranged from 67-546, unadjusted CIR from 91-99%, level 4/5
19
20 comfort scores 3-14% and the average midazolam dosage ranged from 0.8-2.2 mgs for
21
22 patients aged >70, and 1.1-2.4mgs for those aged <70. 25% of procedures were undertaken
23
24 without sedation.
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26

27
28
29 Figure 2 illustrates the relationship of volume of procedures to PICI with four broad groupings:
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- | | | | |
|----|----------------|---|--------------------|
| 32 | A. High volume | – | high PICI (80-90%) |
| 33 | | | |
| 34 | B. High volume | – | low PICI (38%) |
| 35 | | | |
| 36 | C. Low volume | – | high PICI (63-96%) |
| 37 | | | |
| 38 | D. Low volume | – | low PICI (36-47%) |
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44 The single colonoscopist in group B had an unadjusted CIR of 99% and greater use of
45
46 midazolam was the predominant reason for the lower PICI. This colonoscopist has an unusual
47
48 case mix that requires more 'top-up' sedation, including tertiary referrals for resection of large
49
50 polyps and colonoscopy done during hands-on courses. The three colonoscopists in group D
51
52 had unadjusted CIR of 91, 94 and 96% respectively.
53
54

55 56 **Discussion**

1 This paper describes a new performance indicator of colonic intubation that provides a simpler
2 picture of colonoscopist expertise than CIR, comfort and sedation measured separately.

3
4 Moreover, it is better able to identify potentially modifiable colonoscopist and endoscopy unit
5 factors that may affect performance than CIR alone, CIR + comfort or PDR. The PICI may
6 identify individuals in need of additional training more readily than each of its three
7 components. Even though it is principally an indicator of colonic intubation, it complements
8 adenoma detection rate, a surrogate of adequacy of inspection because it is associated with a
9 higher rate of polyp detection.

10
11 The association between patient variables and PICI is similar to that found with CIR in other
12 studies [8,9]: older age; male gender and FOBT-screen positive indication are all associated
13 with a significantly higher likelihood of achieving PICI. PICI has also identified factors that
14 influence colonic intubation not previously reported. JAG-accredited endoscopy units [6],
15 units with one or more magnetic imagers, recently certified colonoscopists, and those with
16 higher annual volumes and higher training status had higher PICI.

17
18 PICI is an intuitive measure of colonic intubation: it is difficult to intubate the colon to the
19 caecum comfortably with minimal sedation. It may also be safer to intubate the caecum with
20 less pain and less sedation. Detecting significant differences in diagnostic colonic perforation is
21 problematic because perforations are not all immediately apparent and because large sample
22 sizes are required to compare rates. Pain occurs when more force is applied to the colon wall
23 so it seems probable that perforation is less likely to occur if the patient is comfortable and
24 awake. Thus a high PICI may become a proxy for safer colonoscopy.

25
26 We examined how PICI compared to established performance indicators such as CIR, PDR and
27 CIR + comfort. PICI was more likely to identify differences in performance related to units and
28 colonoscopists than the other indicators: PICI identified significant differences in 17/25 sub-
29 groups compared to 8/25 for CIR and 8/25 for CIR + comfort alone.

1 The validity of this study depends on the completeness and accuracy of the dataset. It was
2
3 estimated that >90% of the activity that occurred in the audit period was captured [5].
4

5
6 Validation of CIR against endoscopy reporting systems showed a good match between audit
7
8 and reporting system data [5].
9

10
11 Sedation levels and caecal intubation are relatively hard endpoints, while nurse-assessed
12
13 comfort is not. Assessment of comfort of colonoscopy became mandatory in the UK in
14
15 2007[4]. Nurse-assessed comfort is arguably more reliable than patient assessed comfort
16
17 because of the amnesic effect of sedatives. However, differences between units in their
18
19 experience of the scale may have led to inconsistent assessments of nurse-assessed comfort
20
21 but it is difficult to explain how this might have caused systematic bias.
22
23

24
25 Composite performance indicators have potential limitations. We chose to use the median
26
27 dose of midazolam and nurse-assessed comfort of <4 as cut-offs, but do not suggest that
28
29 higher doses of midazolam are inappropriate. It is possible to obtain a high PICI rate (perhaps
30
31 >80-85%) with low CIR and/or an unacceptable proportion of patients having excessive pain.
32
33 Thus a high PICI may only be considered acceptable if there is a minimum CIR (perhaps 90%)
34
35 and maximum level 4/5 pain (perhaps <10% or even lower). Application of the PICI may be
36
37 inappropriate in some situations: complex procedures and procedures performed in hands-on
38
39 courses often take longer and may require 'top-up' sedation.
40
41
42

43
44 The prospectively acquired colonoscopy performance data from a single organisation
45
46 illustrates how PICI might be interpreted and utilised in everyday practice. All colonoscopists
47
48 achieved the required 90% unadjusted CIR, but data showed disparities in performance that
49
50 can be divided into four groups. The high volume colonoscopists have high PICI with the
51
52 exception of one colonoscopist with a unique case mix. Reassuringly, some relatively low
53
54 volume colonoscopists (<200/year) have high a PICI (group C). Thus, according to this measure,
55
56 an annual volume of 100-200 appears to be adequate. However, a second group of low
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1
2 volume colonoscopists have a PICI below the average (54%) in the national audit. The practice
3
4 of these individuals should be subject to further scrutiny. If case mix or other factors cannot
5
6 explain performance, they should consider increasing their annual volume and/or have further
7
8 training. Finally, these data suggest a PICI of 80% is a reasonable minimum performance
9
10 target, and 90% an aspirational one.
11

12
13 This is the first study to demonstrate that endoscopy service accreditation [6] is associated
14
15 with higher performance of colonoscopy. This may be due to the quality enhancing effect of
16
17 accreditation and/or that higher performing units are more likely to get accredited. Units with
18
19 one or more imager had significantly higher numbers of procedures in which PICI was
20
21 achieved. This association disappeared with CIR and CIR + comfort (Table 3) suggesting that
22
23 lower sedation levels in these units did not compromise comfort. However, the presence of
24
25 magnetic imagers might be a marker for another factor that was not captured, such as
26
27 academic status of the unit. In keeping with studies of volume and CIR [10], high annual
28
29 volumes are associated with a higher likelihood of achieving PICI.
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33

34 In the UK, trainees can practice independently after passing a structured competency test [11].
35
36 It is reassuring that these 'independent' trainees perform as well as independent
37
38 colonoscopists and that when a trainee is being trained the PICI is unaffected. These results
39
40 indicate that the government sponsored colonoscopy-training programme, which began in
41
42 2000 has been effective and that patients are not adversely affected by training [12].
43
44
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46 Finally, colonoscopists were assigned to four levels of training exposure: no experience of
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48 courses; attended one or more course; attended a 'training the colonoscopy trainer' course;
49
50 and faculty on courses [13]. At each level of training experience, PICI achievement
51
52 significantly increased. This may indicate that the most able colonoscopists chose to
53
54 participate in and/or deliver courses, and/or that participation improves skills. The most likely
55
56 explanation is that both factors are influential.
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1 It was not possible to determine adenoma detection in this study but many studies have found
2
3 a tight relationship between polyp detection rates (PDR) and adenoma detection rates (ADR)
4
5 [14,15]; thus PDR is regarded as a good proxy for ADR. The significant association between
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The use of propofol for colonoscopy is increasing and now very common in North America,
Australia and some European countries. However, while propofol enhances patient experience
it is more expensive if an anaesthetist is required to administer it. It is possible that propofol is
used by some practitioners to mask poor technique and that with deeper sedation they can
use more force [17]. A recent American study has shown an increased risk of complications in
patients receiving monitored anaesthesia services [18]. There are anecdotal reports of
colonoscopists finding it difficult to colonoscope patients with conscious sedation after being
taught to colonoscope patients with propofol sedation, suggesting propofol sedation limits
skills acquisition. It is proposed that colonoscopists should, prior to using propofol sedation,
demonstrate they are able to achieve a high PICI.

The PICI might be used in two specific circumstances: to identify, support and monitor
individuals in need of improvement and second, for benchmarking. For quality improvement
purposes an individual endoscopy service might create its own PICI measure, using a local
comfort scale and sedation threshold (with minimum levels for CIR and comfort scores). Any
unit that routinely captures all three parameters (virtually all units in the UK) should be able to
use PICI immediately for quality improvement.

In contrast to using PICI to improve quality, all three components of the PICI would need to be
agreed and defined for benchmarking. The principal constraint on this is a reliable
performance measure for comfort: one method would have to be used consistently.

1 A sensible first step would be to use the PICI locally to better identify who might need further
2 skills training. Local jurisdictions, or programme-based screening programmes, might use one
3 method of assessing patient comfort, allowing comparisons of performance between units, as
4 occurs in the English Bowel Cancer Screening Programme. In the UK, the JAG has created a
5 National Endoscopy Database (NED) [19] that draws key indicators from reporting systems.
6 Upload will become compulsory to maintain unit accreditation from 2018. NED uses a single
7 comfort assessment measure so in time it will be possible to compare PICI across the country
8 and explore its relationship to other indicators such as post-colonoscopy colorectal cancer.
9

10 In summary, this study has developed a new performance indicator of colonic intubation. This
11 measure provides a more nuanced picture of intubation skill and one that is better able to
12 detect differences in performance. The study confirms previous findings that age, sex and
13 indication affect performance. New findings are that unit accreditation status, availability of
14 imagers and features of the endoscopist (particularly training status) affect performance. PICI
15 is associated with significantly higher polyp detection. It is proposed that PICI becomes the key
16 performance indicator of colonic intubation for quality improvement of colonoscopy and that
17 80% should be the initial standard for average case mix. In time PICI might also be used to
18 benchmark performance of endoscopy services.
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Table 1: Multivariate modelling – sub groups associated with PICI achievement

Variable ^a	Sub-groups	Odds Ratio (95% CI)	P value ^b
Patient age	<50	0.38 (0.35 to 0.41)	<0.0001
	50 to 59	0.49 (0.45 to 0.54)	<0.0001
	60 to 69	0.61 (0.56 to 0.66)	<0.0001
	70+	Reference	
Patient gender	Male	1.40 (1.32 to 1.49)	<0.0001
	Female	Reference	
Procedure type	Inpatient	Reference	
	Outpatient	0.98 (0.86 to 1.13)	0.78
Procedure indication	Diagnostic	Reference	
	Surveillance	1.09 (1.00 to 1.18)	0.04
	BCSP ^c	1.88 (1.66 to 2.12)	<0.0001
	Screening	1.11 (0.95 to 1.29)	0.19
	Therapeutic	0.87 (0.74 to 1.03)	0.10
Bowel preparation	Poor	Reference	
	Adequate	1.43 (1.30 to 1.58)	<0.0001
	Excellent	1.63 (1.48 to 1.80)	<0.0001
Country	England	Reference	
	Scotland	0.38 (0.34 to 0.43)	<0.0001
	Wales	1.52 (1.27 to 1.81)	<0.0001
	Northern Ireland	1.11 (0.95 to 1.30)	0.19
Unit JAG accreditation status	Accredited	1.26 (1.16 to 1.35)	<0.0001
	Not accredited	Reference	
Imagers per unit	None	Reference	
	One	1.27 (1.18 to 1.37)	<0.0001
	Two or more	1.29 (1.19 to 1.40)	<0.0001
Professional group of colonoscopist	Physician	Reference	
	Surgeon	1.10 (1.03 to 1.18)	0.008
	Nurse	1.09 (0.98 to 1.22)	0.12
	SAS ^d	1.26 (1.06 to 1.51)	0.009
	GP	0.83 (0.63 to 1.10)	0.20
Independent/trainee colonoscopist	Independent	1.12 (0.95 to 1.31)	0.17
	Trainee	Reference	
Number of years independent	0 to 3	Reference	
	3 to 5	1.06 (0.94 to 1.19)	0.36
	5 to 10	0.70 (0.63 to 0.78)	<0.0001
	10 to 20	0.72 (0.65 to 0.80)	<0.0001
	20+	0.67 (0.58 to 0.76)	<0.0001
Annual number of colonoscopies	<100	Reference	
	100 to 199	1.00 (0.91 to 1.10)	0.97
	200 to 299	1.14 (1.03 to 1.26)	0.01
	300 to 499	1.28 (1.15 to 1.42)	<0.0001
	500+	1.13 (1.00 to 1.29)	0.06
Highest level of training	None	Reference	
	Skills	1.16 (1.04 to 1.28)	0.005
	TCT ^e	1.33 (1.21 to 1.47)	<0.0001
	Faculty	1.74 (1.57 to 1.92)	<0.0001
Presence or absence of trainer	Yes	Reference	
	No	0.99 (0.92 to 1.06)	0.73

^a 216 procedures excluded from multivariate model due to missing data (model based on data from 19869 procedures), ^b bold p values indicate statistically significant findings at the p=0.01 level, ^c BCSP = Bowel Cancer Screening Programme, ^d SAS = specialist practitioner, ^e TCT = 'Train the colonoscopy trainer' course

Table 2: Multivariate modelling – sub groups associated with achievement of combined CIR + comfort indicator

Variable ^a	Sub-groups	Odds Ratio (95% CI)	P value ^b
Patient age	<50	0.96 (0.85 to 1.08)	0.557
	50 to 59	1.08 (0.95 to 2.23)	0.234
	60 to 69	0.96 (0.86 to 1.08)	0.518
	70+	Reference	
Patient gender	Male	1.99 (1.83 to 2.18)	<0.0001
	Female	Reference	
Procedure type	Inpatient	Reference	
	Outpatient	1.38 (1.17 to 1.63)	<0.0001
Procedure indication	Diagnostic	Reference	
	Surveillance	1.38 (1.22 to 1.56)	<0.0001
	BCSP ^c	1.53 (1.26 to 1.86)	<0.0001
	Screening	1.22 (0.97 to 1.55)	0.092
	Therapeutic	1.07 (0.84 to 1.36)	0.609
Bowel preparation	Poor	Reference	
	Adequate	2.86 (2.55 to 3.20)	<0.0001
	Excellent	3.41 (3.03 to 3.84)	<0.0001
Country	England	Reference	
	Scotland	0.83 (0.71 to 0.96)	0.014
	Wales	0.70 (0.56 to 0.88)	0.002
	Northern Ireland	1.46 (1.14 to 1.88)	0.003
Unit JAG accreditation status	Accredited	1.07 (0.96 to 1.19)	0.218
	Not accredited	Reference	
Imagers per unit	None	Reference	
	One	1.07 (0.96 to 1.18)	0.226
	Two or more	1.15 (1.02 to 1.29)	0.020
Professional group of colonoscopist	Physician	Reference	
	Surgeon	0.80 (0.72 to 0.88)	<0.0001
	Nurse	0.79 (0.67 to 0.93)	0.004
	SAS ^d	0.76 (0.60 to 0.97)	0.029
	GP	1.12 (0.73 to 1.73)	0.596
Independent/trainee colonoscopist	Independent	0.94 (0.75 to 1.18)	0.579
	Trainee	Reference	
Number of years independent	0 to 3	Reference	
	3 to 5	1.08 (0.91 to 1.28)	0.359
	5 to 10	0.96 (0.83 to 1.10)	0.536
	10 to 20	1.03 (0.88 to 1.19)	0.742
	20+	0.88 (0.73 to 1.06)	0.179
Annual number of colonoscopies	<100	Reference	
	100 to 199	1.06 (0.93 to 1.20)	0.378
	200 to 299	1.15 (0.99 to 1.31)	0.056
	300 to 499	1.38 (1.19 to 1.60)	<0.0001
	500+	1.93 (1.59 to 2.34)	<0.0001
Highest level of training	None	Reference	
	Skills	1.04 (0.91 to 1.19)	0.601
	TCT ^e	1.13 (0.99 to 1.29)	0.082
	Faculty	1.19 (1.04 to 1.37)	0.013
Presence or absence of trainer	Yes	Reference	
	No	1.06 (0.96 to 1.16)	0.251

^a 216 procedures excluded from multivariate model due to missing data (model based on data from 19869 procedures), ^b bold p values indicate statistically significant findings at the p=0.01 level, ^c BCSP = Bowel Cancer Screening Programme, ^d SAS = specialist practitioner, ^e TCT = 'Train the colonoscopy trainer' course

Table 3: Comparison between sub groups in multivariate models that were significant predictors of PCI compared to those that predicted CIR, CIR +comfort and polyp detection

Variable ^a	Sub-groups	P value PCI ^b	P value CIR alone	P value CIR + comfort	P value PDR
Patient age	<50	<0.0001	0.001	0.557	<0.0001
	50 to 59	<0.0001	0.048	0.234	<0.0001
	60 to 69	<0.0001	0.042	0.518	0.091
	70+	-	-	-	-
Patient gender	Male	<0.0001	<0.0001	<0.0001	<0.0001
	Female	-	-	-	-
Procedure type	Inpatient	-	-	-	-
	Outpatient	0.78	<0.0001	<0.0001	0.059
Procedure indication	Diagnostic	-	-	-	-
	Surveillance	0.04	<0.0001	<0.0001	<0.0001
	BCSP ^c	<0.0001	<0.0001	<0.0001	<0.0001
	Screening	0.19	0.204	0.092	<0.0001
	Therapeutic	0.10	0.433	0.609	<0.0001
Bowel preparation	Poor	-	-	-	-
	Adequate	<0.0001	<0.0001	<0.0001	<0.0001
	Excellent	<0.0001	<0.0001	<0.0001	<0.0001
Country	England	-	-	-	-
	Scotland	<0.0001	0.688	0.014	0.140
	Wales	<0.0001	0.089	0.002	0.625
	Northern Ireland	0.19	0.137	0.003	0.425
Unit JAG accreditation status	Accredited	<0.0001	0.006	0.218	0.490
	Not accredited	-	-	-	-
Imagers per unit	None	-	-	-	-
	One	<0.0001	0.226	0.226	0.048
	Two or more	<0.0001	0.020	0.020	0.109
Professional group of colonoscopist	Physician	-	-	-	-
	Surgeon	0.008	<0.0001	<0.0001	0.089
	Nurse	0.12	<0.0001	0.004	0.200
	SAS ^d	0.009	0.181	0.029	0.149
	GP	0.20	0.175	0.596	0.950
Independent/trainee colonoscopist	Independent	0.17	0.562	0.579	0.916
	Trainee	-	-	-	-
Number of years independent	0 to 3	-	-	-	-
	3 to 5	0.36	0.820	0.359	0.206
	5 to 10	<0.0001	0.237	0.536	0.017
	10 to 20	<0.0001	0.871	0.742	<0.0001
	20+	<0.0001	0.017	0.179	<0.0001
Annual number of colonoscopies	<100	-	-	-	-
	100 to 199	0.97	0.309	0.378	0.925
	200 to 299	0.01	0.107	0.056	0.342
	300 to 499	<0.0001	0.002	<0.0001	0.777
	500+	0.06	<0.0001	<0.0001	0.264
Highest level of training	None	-	-	-	-
	Skills	0.005	0.038	0.601	0.578
	TCT ^e	<0.0001	0.009	0.082	0.557
	Faculty	<0.0001	0.445	0.013	0.085
Presence or absence of trainer	Yes	-	-	-	-
	No	0.73	0.445	0.251	0.162

^a 216 procedures excluded from multivariate model due to missing data (model based on data from 19869 procedures), ^b bold p values indicate statistically significant findings at the p=0.01 level, ^c BCSP = Bowel Cancer Screening Programme, ^d SAS = specialist practitioner, ^e TCT = 'Train the colonoscopy trainer' course. Reference categories indicated by hyphenated cells

References

1. Corley D A, Jensen CD, Marks AR et al. Adenoma detection rate and risk of colorectal cancer and death. *N Engl J Med* 2014;370:1298-1306.
2. Kaminski MF, Regula J, Kraszewska E et al. Quality indicators for colonoscopy and the risk of interval cancer. *N Engl J Med* 362:1795-1803.
3. Liu H, Waxman DA, Main R, Mattke S. Utilization of anesthesia services during outpatient endoscopies and colonoscopies and associated spending in 2003-2009. *JAMA* 2012;307:1178-1184.
4. BSG quality and safety indicators for colonoscopy and flexible sigmoidoscopy accessed 14th January 2017 at <http://www.thejag.org.uk/downloads/Unit%20Resources/JAG%20Summary%20guide%20to%20quality%20and%20safety%20indicators%20April%202016.pdf>
5. Gavin DR, Valori RM, Anderson JT, Donnelly MT, Williams JG, Swarbrick, ET. The national colonoscopy audit: a nationwide assessment of the quality and safety of colonoscopy in the UK. *Gut* 2013;62:242-249.
6. Guide to the JAG accreditation scheme accessed 14th January 2017 at <http://www.thejag.org.uk/downloads/Accreditation/Guide%20to%20the%20JAG%20accreditation%20scheme%20v2.pdf>
7. Ekkelenkamp VE, Dowler K, Valori RM, Dunckley P. Patient comfort and quality in colonoscopy. *World J Gastroenterol*. 2013;19:2355-2361.
8. Valori RM, Rey J-F, Atkins WA et al. European guidelines for quality assurance in colorectal cancer screening and diagnosis. First Edition. Quality assurance in endoscopy in colorectal cancer screening and diagnosis. *Endoscopy* 2012; 44: 1–18
9. Rathgaber SW, Wick TM. Colonoscopy completion and complication rates in a community gastroenterology practice. *Gastrointest Endosc*. 2006;64:556–562
10. Enns R. Quality indicators in colonoscopy. *Can J Gastroenterol* 2007;21:277–279

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11. JAG trainee certification process – colonoscopy accessed 14th January 2017 at
<http://www.thejag.org.uk/downloads/JAG%20Certification%20for%20trainees/Colonoscopy%20application%20criteria%20and%20process.pdf>
12. Valori R. Quality Improvements in Endoscopy in England. In: Techniques in Gastrointestinal Endoscopy. 2012;14:63-72
13. JAG endoscopy training courses accessed 14th January 2017 at
<http://www.thejag.org.uk/downloads/JAG%20approved%20training%20courses/JETS%20course%20overview%20v3.0.pdf>
14. Patel NC, Islam RS, Wu Q et al. Measurement of polypectomy rate by using administrative claims data with validation against the adenoma detection rate. Gastrointest Endosc. 2013;77:390-394.
15. Williams JE, Holub JL, Faigel DO. Polypectomy rate is a valid quality measure for colonoscopy: results from a national endoscopy database. Gastrointest Endosc. 2012;75:576-582.
16. James EE, Bassett P, Arebi N, Thomas-Gibson S, Guenther T, Saunders BP. Dynamic patient position changes during colonoscopy withdrawal increase adenoma detection: a randomized, crossover trial. Gastrointestinal Endosc. 2011;73:456–463
17. Korman LY, Haddad NG, Metz DC et al. Effect of propofol anesthesia on force application during colonoscopy. Gastrointest Endosc. 2014;79:657-662.
18. Wernli KJ, Brenner AT, Rutter CM and Inadomi JM. Risks Associated With Anesthesia Services During Colonoscopy. Gastroenterology 2016;150:888–894
19. [http://www.thejag.org.uk/downloads/National%20Endoscopy%20Database%20\(NED\)/NED%20key%20facts%20v1.1.pdf](http://www.thejag.org.uk/downloads/National%20Endoscopy%20Database%20(NED)/NED%20key%20facts%20v1.1.pdf)

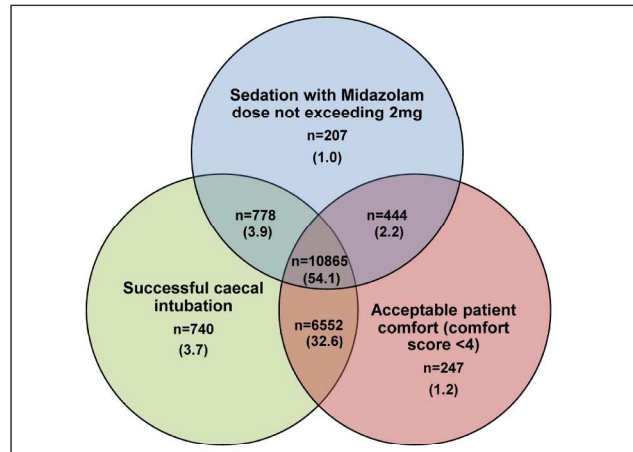
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Figure legends

Figure 1: Number and proportion of procedures comprising each facet of PICI (not shown are 252 procedures (1.3%) in which none of the three quality indicators were achieved)

Figure 2: Relationship of volume to PICI for 5246 colonoscopies performed by 19 colonoscopists in a single institution in one year (2013)

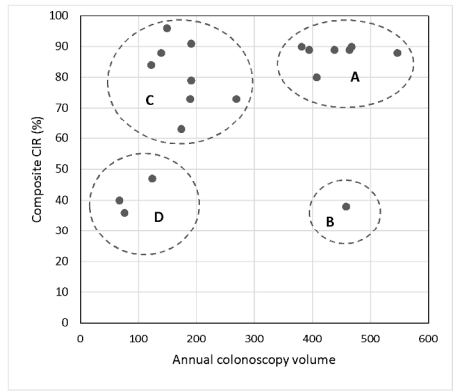
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Number and proportion of procedures comprising each component of PICI (not shown are 252 procedures (1.3%) in which not all the three quality indicators were achieved)

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Relationship of volume to PICI for 5246 colonoscopies performed by 19 colonoscopists in a single institution in one year (2013)
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