**Supplement 1**: Sensitivity analyses of standardized classification ratios at higher or lower thresholds for inclusion based on colonoscopy volume

|  |  |
| --- | --- |
|   | Ratio of Observed/Expected Classification |
| Serrated Polyps | Adenomas |
|   | Low Threshold1 | Main Analysis2 | High Threshold3 | Low Threshold1 | Main Analysis2 | High Threshold3 |
| Min  | 0.36 | 0.36 | 0.28 | 0.88 | 0.90 | 0.90 |
| 25th Percentile | 0.80 | 0.81 | 0.83 | 0.98 | 0.98 | 0.98 |
| Median | 0.96 | 0.95 | 0.964 | 1.00 | 1.00 | 1.00 |
| Mean | 0.98 | 0.97 | 0.98 | 1.00 | 1.00 | 1.00 |
| 75th Percentile | 1.13 | 1.11 | 1.11 | 1.02 | 1.02 | 1.01 |
| Max | 1.89 | 1.89 | 1.81 | 1.20 | 1.08 | 1.09 |
| Std dev | 0.30 | 0.31 | 0.30 | 0.05 | 0.04 | 0.04 |
| Coefficient of Variation | 30.9 | 32.0 | 30.6 | 4.7 | 3.7 | 3.65 |

Notes:

(1) Low threshold: 30 colonoscopies per endoscopist, 100 path reports per pathologist (n=51 pathologists)

(2) Main analysis: 100 colonoscopies per endoscopist, 200 path reports per pathologist (n=48 pathologists)

(3) High threshold: 200 colonoscopies per endoscopist, 300 path reports per pathologist (n=45 pathologists)

**Supplement 2**: Examples of Text from Pathology Reports Describing Serrated Polyps

* Sessile serrated polyp
* Sessile serrated polyp without dysplasia
* Sessile serrated adenoma
* Serrated polyp with morphologic features suggestive of sessile serrated polyp without dysplasia (2 fragments)
* Serrated polyp (1 fragment), favor hyperplastic polyp - No cytologic dysplasia identified
* Serrated polyp with minimal crypt architectural abnormalities, suspicious for sessile serrated polyp without dysplasia (multiple fragments)
* Serrated colonic mucosa with features compatible with sessile serrated polyp.
* Fragments of sessile serrated adenoma
* Colonic mucosa with serrated changes suggestive of sessile serrated adenoma.
* Tubular adenoma some with serrated features
* Fragments of sessile serrated adenoma…multiple fragments of sessile serrated adenoma(s) and hyperplastic
* Two pieces of serrated polyp with associated low grade cytologic dysplasia
* Sessile serrated adenoma
* Minute sessile serrated polyp, cannot exclude sessile serrated adenoma

**Supplement 3**: Comparing Pathologists’ Observed Classification and Standardized Classification Ratios for Adenomas and Serrated Polyps

A pathologist’s observed classification ratio is her raw rate of adenoma or serrated polyp classification (i.e. the number of adenomas classified by the pathologist / the number of pathology reports he reviewed). The standardized classification ratio is the ratio of the pathologist’s observed classification ratio to the pathologist’s “expected classification ratio.” We calculate the expected classification ratio as described in the main text, using recycled prediction from logistic regression with endoscopist fixed effects.

*Figure A3: Histograms of observed classification ratio (left) and standardized classification ratio (right) for adenomas (top) and serrated polyps (bottom).*

FIGURE SUBMITTED SEPARATELY

*Table A3: Descriptive statistics for classification ratios for adenomas and serrated polyps, raw and standardized*

|  |  |  |
| --- | --- | --- |
|  | Unadjusted | Standardized |
|  | Serrated Polyps | Adenomas | Serrated Polyps | Adenomas |
|
| Min  | 0.01 | 0.48 | 0.36 | 0.90 |
| 25th Percentile | 0.08 | 0.53 | 0.81 | 0.98 |
| Median | 0.11 | 0.60 | 0.95 | 1.00 |
| Mean | 0.11 | 0.59 | 0.97 | 1.00 |
| 75th Percentile | 0.15 | 0.64 | 1.11 | 1.02 |
| Max | 0.20 | 0.71 | 1.89 | 1.08 |
| Std dev | 0.05 | 0.06 | 0.31 | 0.04 |
| Coefficient of Variation | 41.7 | 10.3 | 32.0 | 3.7 |

**Supplement 4:** Sensitivity analysis including patient age, gender and colonoscopy indication (in addition to endoscopist) in models assessing the predicted probability of classifying an adenoma or serrated polyp

We conducted a sensitivity analysis adjusting for patient age, sex and colonoscopy indication in the calculation of the standardized risk ratios. The correlation between a pathologist’s unadjusted and adjusted standardized risk ratios for adenoma classification was 0.9912, and for serrated polyp classification was 0.9998.

*Figure A4.1: Pathologist variation in ratio of standardized adenoma classification ratio and standardized serrated polyp classification ratio, including patient characteristics*

FIGURE SUBMITTED SEPARATELY

 *Figure A4.2: Pathologist variation in ratio of standardized adenoma classification ratio and standardized serrated polyp classification ratio, without adjusting for patient characteristics (primary analysis)*

FIGURE SUBMITTED SEPARATELY

Notes:

(1) n=48 pathologists with 50,453 pathology reports.

(2) Path reports from physicians who performed fewer than 100 colonoscopies over the study period were excluded.

(3) Pathologists who analyze fewer than 200 pathology reports over the study period were excluded.

**Supplement 5**

We will use endoscopists’ maximum-bound adenoma detection rate (“high ADR”) as an example to illustrate how these counterfactual adenoma and serrated polyp detection rates were calculated. This calculation represents the adenoma detection rate that the endoscopist would have had if he or she had sent all of his or her colonoscopy specimins to the pathologist in the sample with the maximum adenoma (AD) classification rate. Each pathologist’s adenoma classification rate is defined as the number of colonoscopies in which an adenoma was detected divided by the number of colonoscopies with a polyp removed and an associated pathology report analyzed by that pathologist. We will describe these calculations using the equation below and the table, which has data for two of the endoscopists in our sample.

For each endoscopist we observe the total number of colonoscopies they performed (column A), the number of colonoscopies in which a polyp was removed and an associated pathology report was identified (B), the total number of adenomas detected (C), and their observed adenoma detection rate (D, calculated as total number of colonoscopies with an adenoma divided by the total number of colonoscopies).

We also observe which pathologists the endoscopists sent their specimens to. Both Provider 1 and Provider 2 from the table below sent their specimens to three pathologists (Patho1 Patho2 and Patho3). Colums E-J report the classification rate for each of the three pathologists as well as the volume of that endoscopist’s specimens that each pathologist analyzed. We then take the volume-weighted average of the endoscopist’s pathologists’ adenoma classification rates (K). We also calculate the endoscopist’s adenoma classification rate (L, calculated as the number of colonoscopies with an adenoma detected/number of colonoscopies with a polyp removed and an associated pathology report).

Finally, we take the ratio of the maximum pathologist adenoma classification rate (71%) to the volume-weighted average of that endoscopist’s classification rate (column K) and multiply it by the number of adenomas detected by the endoscopist. We then take that product and divide it by the total number of colonoscopies performed by the endoscopist to get the endoscopists’ counterfactual “high ADR.”

We performed this calculation using the highest-classifying pathologist, as described above, as well as the lowest-classifying pathologist, the pathologist at the 25th percentile of classification, and the pathologist at the 75th percentile of classification. In the manuscript, we report a series of numbers based on these calculations, including the range of their counterfactual “low ADR” and “high ADR” (and SPDR) across endoscopists. We only present these using the highest- and lowest-classifying pathologists (e.g. we do not present this range or include a corresponding figure when discussing the range of the impact on endoscopist outcomes from sending their specimens to a pathologist at the 25th or 75th percentile of classification). This is because the calculations using the 25th and 75th percentile produce some non-intuitive results. For example, by definition, some endoscopists in our sample do actually send their specimens to be analyzed by pathologists above the 75th percentile of adenoma classification. For those endoscopists, the counterfactual ADR based on pathologists at the 75th percentile is *lower* than their observed ADR. In addition, endoscopists who actually their specimens to pathologists below the 25th percentile of adenoma classification could have their counterfactual ADR based on the pathologist at the 25th percentile deflated to an ADR below 0%. Given the non-intuitive interpretation of these ranges, we chose only to present the average increase and decrease in ADR and SPDR when considering the impact of sending specimens to the pathologists at the 25th and 75th percentiles of classification. Finally, it’s important to emphasize that this analytical exercise is meant to demonstrate the substantial impact that pathologist classification rates can have on endoscopist quality outcomes, and does not imply any particular “optimal” pathologist classification rate for adenomas or serrated polyps.

**Supplement 5, cont'd**

*Equation A5.1: Formula for “High ADR”*

$$High ADR=\frac{\frac{maximum pathologist AD classification rate}{volume weighted average of endoscopist^{'}spathologists^{'}AD classification rates}\*number of adenomas detected by endoscopist}{total number of colonoscopies performed by the endoscopist}$$

*Table A5.1: Example calculations*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Endoscopist Observed Characteristics | Endoscopist’s Pathologists’ Characteristics | Endoscopist Calculated Outcomes |
| Label | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|  | To-tal # Col. | Total # Polyps Removed w/ Path Report | Total # Ad. | Obse-rved ADR | Patho1 Class. Rate | Patho1 Vol Analyzed | Patho2 Class. Rate | Patho2 Vol Analyzed | Patho3 Class. Rate | Patho3 Vol Analyzed | Volume-Weighted Avg of Patho Class. Rate | Endosc-opist Ad. Class. Rate | High ADR | Low ADR |
| Provider 1 | 693 | 472 | 310 | 0.45 | 0.62 | 46 | 0.66 | 99 | 0.66 | 327 | 0.66 | 0.66 | 0.48 | 0.32 |
| Provider 2 | 457 | 240 | 169 | 0.37 | 0.62 | 46 | 0.66 | 17 | 0.66 | 177 | 0.65 | 0.70 | 0.40 | 0.27 |

*Table A5.2: Classification Rates*

|  |
| --- |
| *Adenoma classification rates among pathologists in the sample* |
| Highest  | 71% |
| 75th percentile  | 64% |
| 25th percentile  | 53% |
| Lowest  | 48% |
| *Serrated polyp classification rates among pathologists in the sample* |
| Highest  | 20% |
| 75th percentile  | 15% |
| 25th percentile  | 8% |
| Lowest  | 1% |

Note: a pathologist’s adenoma classification rate is defined as the number of colonoscopies in which an adenoma was detected divided by the number of colonoscopies with a polyp removed and an associated pathology report analyzed by that pathologist

**Supplement 6**: Comparison of Pathologist Sample to National Pathologist Characteristics

|  |  |  |
| --- | --- | --- |
|   | Study Sample | National Population |
| Total | n=48 | n=18,093 |
|   | % | % |
| Sex |
| Male | 63.5 | 63.8 |
| Female | 37.5 | 36.2 |
| Years in practice |
| <8 | 33.3 | 20.2 |
| 8-17 | 35.4 | 23.7 |
| 18-46 | 31.3 | 56.2 |

Notes:
(1) Data from Doximity

**Supplement 7**: Calculation of Standardized Serrated Polyp Classification Ratio

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pathologist | Volume of Pathology Reports | Observed Serrated Polyp Classification | Expected SP Classification, Adjusted for Endoscopist | Observed/Expected Ratio |
| A | 4497 | 20.3% | 19.0% | 1.07 |
| B | 2729 | 6.9% | 10.4% | 0.66 |
| C | 1863 | 19.1% | 10.4% | 1.83 |
| D | 1741 | 8.5% | 10.4% | 0.81 |
| E | 1661 | 10.8% | 11.3% | 0.96 |
| F | 1546 | 9.0% | 8.2% | 1.09 |
| G | 1430 | 12.7% | 11.4% | 1.11 |
| H | 1420 | 15.9% | 18.5% | 0.86 |
| I | 1410 | 9.1% | 8.5% | 1.07 |
| J | 4497 | 20.3% | 19.0% | 1.07 |

Notes:

(1) Shown for the ten pathologists with the highest volume of pathology reports in the sample

**Supplement 8:** Pathologist variation in standardized serrated polyp classification ratio by location of serrated polyp, using alternative cutoffs for colonic segments

FIGURE SUBMITTED SEPARATELY

Notes:

(1) n=48 pathologists with 50,453 pathology reports.

(2) Path reports from physicians who performed fewer than 100 colonoscopies over the study period were excluded.

(3) Pathologists who analyze fewer than 200 pathology reports over the study period were excluded.

(4) Proximal colon defined as proximal to the splenic flexure, >50 cm from anal verge; distal colon defined as end of the rectum to the splenic flexure, including the sigmoid colon, 15-50 cm from anal verge; and the rectum, ≤15cm from anal verge